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EDITORIAL.

ITEMS AND NOVELTIES.

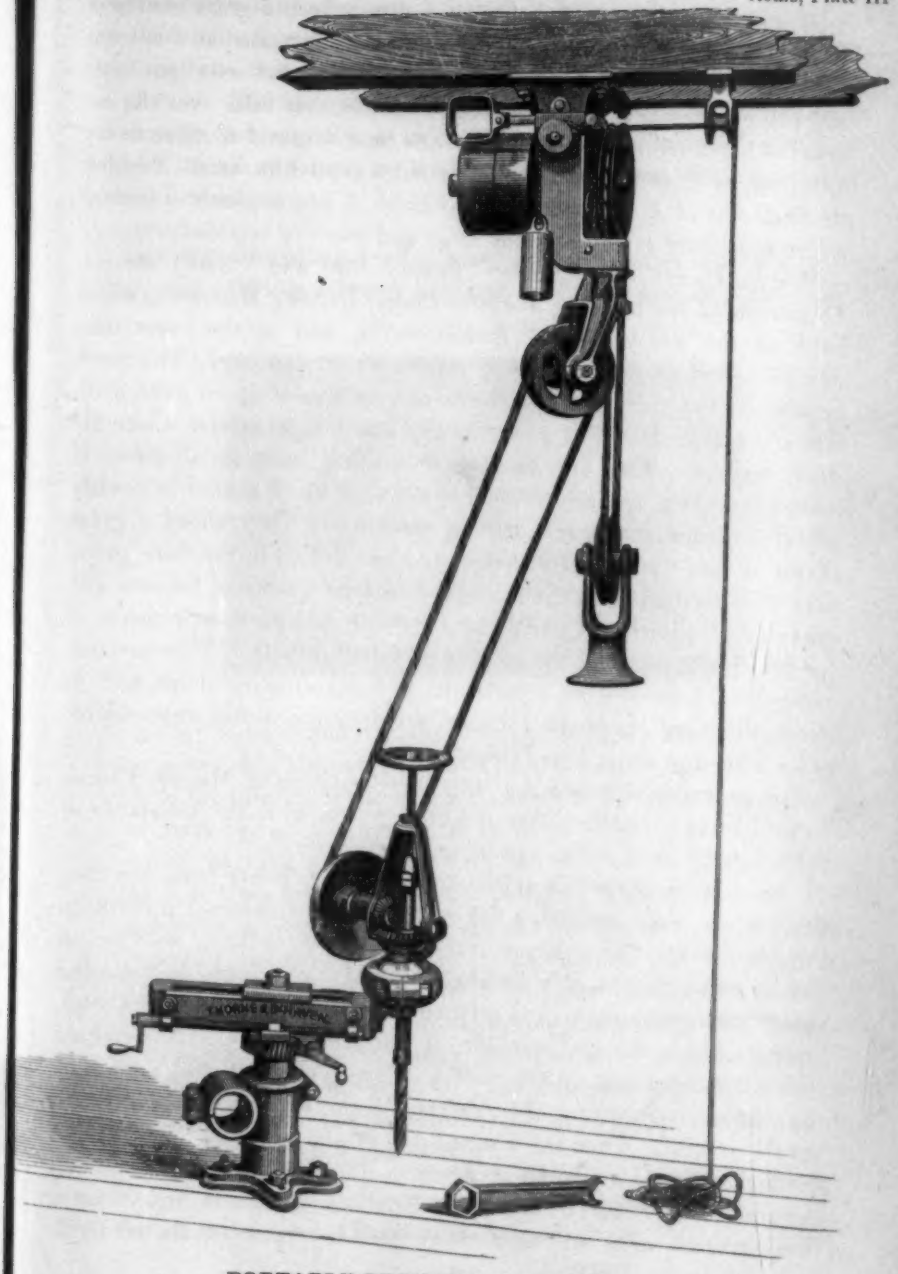
Portable Drilling Machines.—It is becoming an acknowledged principle in machine-shop practice that, where a machine tool, intended to operate upon a piece of work, is lighter and more easily handled than the work, it is cheaper to move the tool to the work than the work to the tool. The great difficulty has been to put this principle into practice. Until within late years, machinery has been designed so that the framing and heavy parts were made up in sections and bolted together, thereby greatly multiplying the surfaces and joints to be fitted, increasing the amount of work necessary, and rendering more difficult the attainment of accuracy and the consequent successful working and durability of the machinery. This plan was adopted, not from preference, but from the difficulty of handling heavy pieces, and the want of tools adapted to heavy work. At present, we find engineers making their designs so as to throw as much of the work as possible on to the foundry, and as little as possible to the machine-shop. Heavy castings and few joints are cheaper in construction, more accurate when done, and more durable in use.

One great difficulty is found to be drilling the holes for bolts, &c., in large and heavy iron work. This has always been a great source of delay and expense in machine construction. The Radial Drill was designed to overcome this, and proved a useful and excellent tool; but, being stationary, was often found to save but little over the expense of hand-drilling, on account of the time required to move heavy beds, &c., to it, merely to have a few holes drilled in them. Besides, the first cost of a stationary Radial Drill of any capacity is such as to preclude their use by any but large and wealthy establishments.

Messrs. Thorne & De Haven (Twenty-third and Cherry streets, Philadelphia) are building *Portable* Radial Drilling Machines, which have all the advantages of Radial Drills, and at the same time can be bolted to heavy parts of machinery or iron work, with much greater facility than a ratchet-brace can be rigged up for hand-drilling, and can be driven by power in any position, no matter where the work may be. They are adapted to drilling holes in all pieces of machinery which are inconvenient to move, or which cannot be readily adjusted under stationary drilling machines. They afford a great saving of time where several holes are to be drilled in the same piece, even where a drill-press could be used, in consequence of the ease and accuracy of adjustment gained by the screw and worm movements of the radial arm carrying the gearing and drill-spindle. They are specially needed in marine, locomotive and all erecting-shops, and in yards adjoining shops, on columns, architectural work, water-mains, gas-works, iron ships, iron bridges, &c.

The accompanying cut is a true representation of Messrs. Thorne & De Haven's smallest size machine, which, with the assistance of the following description, can be easily understood.

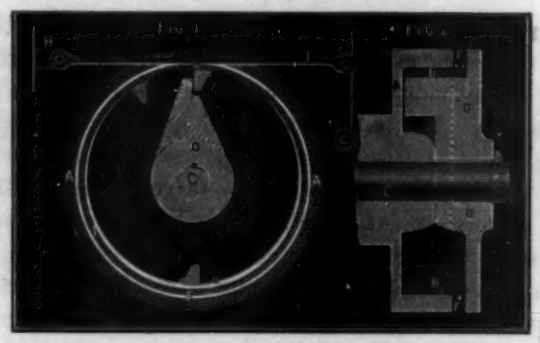
The counter-hanger is stationary, receiving power from the line-shaft of the shop through a flat belt on "fast-and-loose" pulleys, in the usual way. The power is transmitted to the drilling machine, in any direction and to any distance, by means of a round belt passing over "idler" pulleys, held in a frame, which rotates on a hollow stud, through which the pulling side of the belt passes. A weighted "idler" pulley hangs on the "slack" side of the belt, and maintains the tension, permitting the distance of the drilling machine to be varied at will. When the rise and fall of the weighted "idler" does not give sufficient variation of distance, additional lengths of belt can be inserted by means of the hook couplings used, and any distance thus obtained. The drilling-machine itself is a complete Radial Drill.



PORTABLE DRILLING MACHINE.

The height of its post can be varied to suit different lengths of drills and chucks; the radial arm is travelled by a screw and rotated by a worm and tangent wheel; the cone pulley has four steps for four speeds; the drill spindle can be set to an angle with the base in any direction. The base of the machine can be bolted to the work, either vertically, horizontally, or in any plane. It can be used to drill parallel with its own base, by holding the post in the clamp-bearing on side of base.

Spring Coupling.‡—The accompanying figures represent a form of spring coupling recently patented in France and England. A, is



the pulley to be driven; C, the driving shaft, the latter carrying a driving arm, D. The outer end of this arm presses against a stop b″, fixed to the interior of the spring B, which is surrounded by leather or other packing, I. The spring B tends to expand and force the surrounding packing into contact with the part of the pulley A within which it is placed, thus driving the pulley by frictional contact. When it is desired to stop the pulley, various arrangements may be used for compressing the spring and destroying contact. In the figure here given, the tightening of the cord F produces the desired result. If the pulley A is made the driver, the device which compresses the spring and disengages it from the pulley, will also serve to act as a brake to arrest the motion of the shaft C. The minimum grip of the stop occurs when it is in the position b; it will be greater at b′, and will reach a maximum when placed at b″.

J. H. C.

‡ Engineering, 1871, 361.

A Huge Chimney.*—To obviate the annoyance caused the inhabitants by the contamination of the air, from the fumes of neighboring cement kilns at Dover Court, England, the proprietor is having a gigantic shaft constructed. The structure is remarkably well built, formed of the hardest red bricks and the best cement of the district. Its height when finished will be upwards of 190 feet. It is square built, and 20 feet square at the base; while at the summit, capped with stone, it is to be 8 ft. 6 in. across. A brick tunnel, 100 feet in length and of large size, will connect the great landmark with the apices of the several kilns. By being carried to so great an elevation, the irritating fumes from the kilns will be diffused over so great an area as to become practically harmless and inoffensive.

An Improved Transit.—At the last meeting of the Franklin Institute there was exhibited and described an instrument of this character, devised and manufactured by Messrs. Heller and Brightley of this city. The instrument is the kind known to engineers as the "long centre" transit; and the points of modification which the inventors claim as improvements, are here briefly condensed. The weight of the instrument is reduced one-half as compared to the ordinary long centre transit, while its size is not diminished in any part. This is accomplished by ribbing or bracing the plates and other solid parts, while every superfluous particle of metal not essential to the strength or steadiness of the instrument is removed.

The errors arising from the wear of the "tangent or slow motion screw," which in time becomes very serious, the inventors claim to have obviated by an improved tangent screw having the following construction. The nut consists of a long cylinder, from the interior of which two-thirds of the screw thread has been removed; into half the recess thus left in the cylinder, a cylindrical "follower" is fitted with the same length of thread as the nut. A "key" in the follower locking in the cylinder, prevents any rotary motion of the follower, but freely permits motion forwards or backwards. A strong spiral spring is placed in the remaining half of the recess, between the fixed nut and the movable follower, in such manner that it shall always possess tension enough to force the follower and fixed thread in opposite directions. The difficulty of lost motion in the screw is thus claimed to be removed. The tangent screw is attached to the plates by a modification of the "gimbelling" of the ship's compass,

* Mechanics Magazine, Sept., 1871.

so as to permit the screw to be tangent to the plates in every part of its length and not to bind.

An improved telescope, in which chromatic and spherical abberration are for practical purposes completely corrected, is also claimed.

The spiders web, hitherto used for cross hairs, being hygrometric, and hence liable in tunnel work, &c., to lengthen and shift the line of collimation, is replaced in the instrument here described, by cross hairs of platinum $\frac{1}{1000}$ of an inch in thickness. These being perfectly independent of this atmospheric source of error, and at the same time perfectly opaque, are a most valuable substitute.

The extremely thin wire, it may be mentioned, is manufactured upon the plan first suggested by Wollaston, of covering a thin wire of platinum with silver, drawing the two metals together, and subsequently dissolving off the surrounding silver from the central platinum.

A new use for the screw Propeller.*—M. Marten suggests the plan of attaching to sailing-vessels a screw-propeller, the motion of which shall be obtained from the movement of the ship. The author proposes to utilize the power so obtained, in giving motion to an electro-magnetic apparatus, from which such vessels may be supplied with the convenience of an electric light, thus dispensing with the use of oil, and gaining besides the advantage of the greatly increased illumination.

The Rotary Puddling Furnace.—The invention of Mr. Danks, noticed some months ago in this journal, by which the manual labor of puddling is performed entirely by a machine which he has termed the rotary puddling furnace, is at present attracting great attention from English iron-masters. The most glowing accounts of its performance have reached us from Cincinnati, where it was first put into operation. And if but a portion of these accounts are genuine, the machine puddler bids fair to work a great change in one of the most important branches of iron manufacture.

Dynamite.—The substitution of parchment for paper in the material of the cartridge cases intended to contain dynamite, (nitroglycerine absorbed by an inert powder,) is strongly urged by M. Guyot, who has found that the papers in which this substance is usually placed, soon become oily from having saturated themselves with

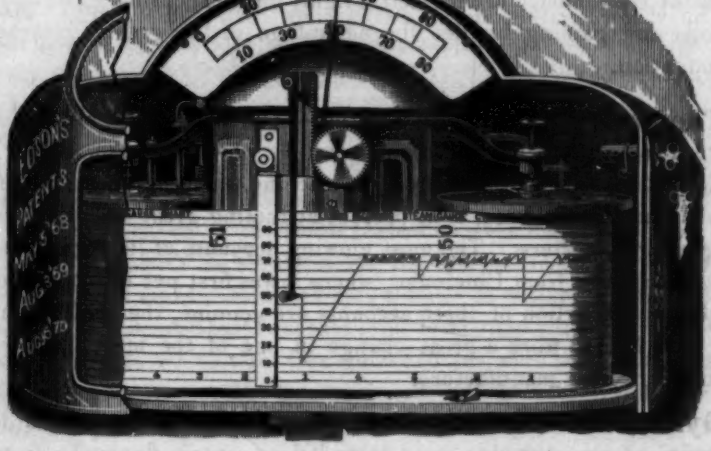
* Les Mondes, Aug. 24, 1871.

the nitro-glycerine. Small pieces of such paper were found to explode with violence when thrown upon glowing coals, or struck with a hammer. Even the wooden boxes in which it is transported, become after a time strongly impregnated with this dangerous compound.

The author points out very clearly that the facts here detailed may give rise to serious accidents, where this material is stored or used.

The use of parchment is recommended as a substitute for the paper, as the former being impervious to the liquid, no absorption of the nitro-glycerine can take place.

An Automatic Registering Steam Gauge.—As a matter of interest to many of our readers who may have heard of the fact that the Edson Steam Recording Gauge has recently been adopted by the U. S. Government Inspectors for use upon steamers, &c., in conformity with the recently enactly steamboat law (see this *Journal*, Vol. lxii, p. 223), we append herewith an illustration and description of its construction and working:



The gauge is connected with the boiler by means of a pipe, which allows the steam to act upon a series of corrugated discs, arranged

in pairs, and which are expanded by it. The motion thus produced is transmitted to a wheel (shown in the cut) by means of a lever.

This wheel communicates motion to a rack, carrying a pencil, which marks the varying degrees of pressure upon a band of paper, which receives its motion from the same source; the drum upon the left unwinding and that upon the right winding up the band.

At the side of the pencil will be seen a scale, by which the pressure momentarily recorded may be read with great convenience. With a rising pressure, the pencil marks a stroke directly upwards; when the pressure falls, a forward motion is communicated to the paper, and the recorded mark is at an angle. The record is an extremely delicate one, the line being composed frequently of an innumerable number of slight notches, so close together as to seem a horizontal line, the cause being the slight variation of pressure at the successive strokes of the engine—a few ounces at most.

The paper roll will last for many weeks, and when used up may be filed away for reference. Another device, suitably attached to the instrument, causes an alarm to be rung whenever the pressure exceeds that determined upon on locking the case. Unless steam is promptly lowered, the gong continues to sound for half an hour or more.

The whole contrivance is secured by combination locks, which prevents it from being tampered with; and the case is fronted with a glass plate, to allow passengers and others to inspect momentarily the condition of the steam in the boiler.

The Introduction of the Metrical System.—Since writing our last notice upon this important question, we have obtained some additional information through the kindness of Prof. J. E Hilgard, acting Superintendent of weights and measures. From this it appears that there are in the custody of the Treasury Department, at the office of weights and measures, the following authentic copies of the standard meter and kilogramme of France, viz.: Meter of platinum, compared and certified by Arago. Meter of steel, compared and certified by Silbermann. Kilogramme of platinum, compared and certified by Arago. Kilogramme of brass (gilt) compared and certified by Silbermann.

The length of the meter is 39·3685 inches of the United States standard scale, and the kilogramme is 15,432·2 grains, or 2 pounds, 3 ounces, 119·7 grains avoirdupois.

These numbers are exact for the meter within $\frac{3}{10000}$ of an inch; for the kilogramme, within $\frac{1}{10}$ of a grain. The standards obtained possess as great a degree of authenticity as can be obtained, and may be regarded as being as nearly perfect as they can be made.

In addition to the standards here enumerated, there is in the possession of the U. S. Coast Survey an iron meter, to which an unusual degree of authenticity is attached.

This instrument is the property of the American Philosophical Society, and is one of the twelve original meters made by direct comparison with the toise. A comparison between this bar and the standard of France at the Conservatory of Arts and Trades, was effected by Dr. F. A. Barnard, with the result, that at the temperature of melting ice there is no appreciable difference, by the most delicate means of comparison, between the platinum standard of the conservatory and the iron meter above named. It is therefore possible to reproduce the metric standards with all possible freedom from error.

The kind, form and verification of the standards to be supplied to the various States and Territories, was agreed upon by the National Academy of Sciences, and subsequently approved. The verification of each set is made in duplicate by different persons. At the date of the report from which we quote, the work of construction, adjustment and graduation is in a very advanced state.

Boussingault's Experiment with Confined Water.—The author relates the following experiment, conducted by him in order to test the condition of water, when cooled considerably below its normal freezing point, under circumstances where free expansion was prevented. For this purpose, a strong cylinder of steel was filled with water at the temperature of maximum density, and a steel plug tightly fitted to the opening, thus preventing, by the strength and the practically unyielding nature of the confining vessel, any expansion of the contained liquid when cooled. The sound made by the falling of a metal ball previously placed within the cylinder, gave an indication of the condition of its contents. Under these circumstances, Boussingault found that water remains liquid even at a temperature of —18° C.$\frac{1}{4}$(—0·4° Fahr.), but freezes instantly as soon as the plug, which

hermetically sealed the vessel, is removed, and its particles are allowed full freedom to expand.

The Bending of Glacier Ice.—The announcement having been made that ordinary ice, when subjected to a transverse strain, would bend sufficiently to admit of measuring the extent of flexure, Tyndall, some time since, suggested that the same test should be applied to glacier ice. It has been left, however, for Prof. T. himself to carry out his suggestion, which he has done successfully. The ice was a rectangular bar from the Morteratsch glacier, and was suspended at the ends and weighted at the centre, the temperature being kept some degrees below the freezing point. After the lapse of ten or twelve hours a perceptible curvature was noticable. Whether or not this fact will, in any degree, affect the still-contested problem of glacier motion remains to be seen.

Transparent Lacs for Glass and Mica.*—F. Springmühl informs us that the aniline colors are particularly well adapted for the manufacture of transparent lacs, which possess great intensity even in very thin films, and are hence very suitable for coloring glass or mica.

The process recommended, is to prepare separately an alcoholic solution of bleached shellac or sandarach, and a concentrated alcoholic solution of the coloring matter, which last is added to the lac before using it, the glass or mica to be coated being slightly warmed. Colored films of great beauty may also be obtained, according to the author, from colored solutions of gun-cotton in ether, the coloring matter being here dissolved in alcohol and ether.

The collodion film has its elasticity greatly increased by the addition of some turpentine oil; and when applied cold can be removed entire. The colored films may now be cut into any pattern, and again attached to transparent objects.

The Bright Lines in the Spectrum of the Chromosphere.—Through the kindness of Prof. C. A. Young, Ph. D., we have obtained advance sheets of the Amer. Jour. of Science, containing an article upon the bright lines in the chromosphere, observed and catalogued by the author. The catalogue, which is a most valuable addition to our knowledge, is herewith appended. The only column needing a word of explanation is the seventh, in which the letters R., L. and J., refer respectively to Rayat, Lockyer and Janssen:

* Zeitsch. für Färberei, etc., No. 20, 1871.

Preliminary Catalogue of Chromospheric Lines.

Ref. No.	Kirchhoff.	Angstrom.	Rel. Frequency.	Rel. Brightness.	Chemical Element.	Previous Observer.
*1	534·5	7060·?	60	3		
2	654·5	6677·?	8	4		L.
3	C	6561·8	100	100	H.	L. J.
4	719·0	6495·7	2	2	Ba.	
5	734·0	6454·5	2	3		
6	743·?	6431·	2	2		
7	768·?	6370·	2	2		
8	816·8	6260·3	1	1	Ti.	
9	820·0	6253·2	1	2	Fe.	
10	874·2	6140·5	6	8	Ba.	L.
11	D_1	5894·8	10	10	Na.	L.
12	D_2	5889·0	10	10	Na.	L.
*13	1017·0	5871·	100	75		L. J.
14	1274·3	5534·0	6	8	Ba.	R. L.
15	1281·5	5526·0	1	1	Fe.	
16	1343·5	5454·5	1	2	Fe.	
17	1351·3	5445·9	1	2	Fe. Ti.	
18	1363·1	5443·0	1	1	Fe.	
*19	1366·0	5430·0	2	3		
20	1372·0	5424·5	3	4	Ba.	L.
21	1378·5?	5418·0?	1	2	Ti.?	
*22	1382·5	5412·	1	1		
23	1391·2	5403·0	2	2	Fe, Ti.	
24	1397·8	5396·2	1	2	Fe.	
25	1421·5	5370·4	1	2	Fe.	R.
26	1431·3	5360·6	2	2		R.?
27	1454·7	5332·0	2	2	Ti.	
28	1462·9	5327·7	1	3	Fe.	
29	1463·4	5327·2	1	3	Fe.	
30	1465·0?	5321·	2	2		
	Corn'a line					
31	1474·1	5315·9	75	15	Fe.?	L.
32	1505·5	5283·	5	4		
33	1515·5	5275·0	7	5		L. R.
34	E_1	5269·5	1	3	Fe, Ca.	
35	E_2	5268·5	1	2	Fe.	
36	1528·0	5265·5	3	2	Fe, Co.	L.
37	1561·0	5239·0	1	1	Fe.	
38	1564·1	5236·2	1	1		
39	1567·7	5233·5	2	2	Mn.	R.
40	1569·7	5232·0	1	2	Fe.	
41	1577·3	5226·0	1	2	Fe.	
42	1580·5?	5224·5	1	1	Ti.	
43	1601·5	5207·3	3	3	Cr. Fe.?	
44	1604·4	5395·3	3	3	Cr.	
45	1606·5	5203·7	3	3	Cr, Fe.?	
46	1609·3	5201·6	1	2	Fe.	
47	1611·5	5199·5	1	1		
48	1615·6	5197·0	3	2		L. R.
49	b_1	5183·0	15	15	Mg.	L.
50	b_2	5172·0	15	15	Mg.	L.
51	b_3	5168·5	12	10	Ni.	L.
52	b_4	5166·5	10	10	Mg.	L.
53	1673·9	5153·2	1	1	Na.	
54	1678·0	5150·1	1	2	Fe.	
55	1778·5	5077·8	1	1	Fe.	
56	1866·8	5017·5	2	3		R.
57	1870·3	5015·?	2	2		R.
58	1989·5	4933·4	8	5	Ba.	L.
59	2001·5	4923·2	5	3	Fe.	R. L.
60	2003·2	4921·3	1	1		
61	2007·1	4918·1	3	3		L.
62	2031·0	4899·3	6	4	Ba.	L.
63	2051·5	4882·5	2	2		L.
64	F.	4860·6	100	75	H.	J. L.
65	2358·5	4629·0	1	1	Ti.	
66	2419·3	4583·5	1	1		
67	2435·5	4571·4	1	1	Li.	
68	2444·0	4564·6	1	1		
69	2446·6	4563·1	1	2	Ti.	
70	2457·8	4555·0	1	1	Ti.	
71	2461·2	4553·3	3	3	Ba.	
72	2467·7	4548·7	1	3	Ti.	
73	2486·8	4535·2	1	1	Ti. Ca.?	
74	2489·5	4533·2	1	1	Fe.	
75	2490·6	4531·7	1	1	Ti.	
76	2502·5	4524·2	2	2	Ba.	
77	2505·8	4522·1	1	2	Ti.	
78	2537·3	4500·4	1	3	Ti.	
79	2553·?	4491·0?	1	1	Mn.?	
80	2555·?	4489·5?	1	1	Mn.?	
81	2566·5	4480·4	1	2	Mg.	L.
82	2581·5?	4471·4	75	8	A band rather than a line.	
83	2585·5	4468·6	1	1	Ti.	
84	2625·0	4443·0	1	1	Ti.	
85	2670·0	4414·6	1	1	Fe. Mn.	
86	2686·7	4404·3	1	2	Fe.	
87	2705·0	4393·5	3	2	Ti.	
88	2719·?	4384·8	1	1	Ca.?	
89	2721·2	4382·7	1	2	Fe.	
90	2734·?	4372·	1	1		
91	2737·?	4369·3?	1	1	Cr.?	
92	2775·8	4352·0	1	1	Fe. Cr.	
93	2796·0	4340·0	100	50	H.	L. J.
94	G.	4307·0	1	2	Fe. Ti. Ca.	
95	2770·0	4300·0	1	1	Ti.	
96		4297·5	1	1	Ti. Ca.	
97		4289·0	1	2	Cr.	
98		4274·5	1	2	Cr.	
99		4260·0	1	1	Fe.	
100		4245·2	1	1	Fe.	
101		4226·5	1	1	Ca.	
102		4215·5	1	2	Fe. Ca.	
103	h	4101·2	100	20	H.	R. L.

A Volcano in Miniature.*—Dr. Ferd. W. Hochstetter furnishes an interesting account of a phenomenon occurring during one of the phases of a manufacturing operation, which is, as he claims, a complete duplicate, upon a miniature scale, of a volcanic eruption, and which serves, at the same time, to confirm the modern views concerning the process of an eruption; according to which the lava is not simply in a molten condition, but is reduced to the state of liquidity by the action of superheated water-vapor under great pressure.

The phenomenon referred to occurs in the operation of separating the sulphur from the residual products obtained in the manufacture of soda by Leblanc's process. The sulphur obtained from these residues, in order to free it from the gypsum or sulphate of lime mixed with it, is melted in a suitable apparatus, with steam under a pressure of from 2—3 atmospheres. The gypsum remains suspended in the water, and the fused sulphur is from time to time run off into wooden troughs or forms, the temperature of the fluid mass being about 122°C. (251·6°F.) Almost instantly after the pouring, a crust of solid sulphur is formed on the surface of the mass. Dotted over this surface, however, the orifices are left, from which the liquid beneath is forced up. At intervals a jet of sulphur bubbles out, and cooling, forms around the orifice a slight prominence; the repeated eruptions accumulate material about it, until a miniature volcanic cone is formed, with its crater well defined.

The cause of this curious phenomenon is found in the fact that the sulphur, in its fused condition in the steam chamber, takes up and retains a certain quantity of water; and this absorbed water, it appears, is given out gradually in the form of steam, as the sulphur solidifies. The slowly liberated steam accumulating pressure beneath the crust of sulphur, forces, at regular intervals, an outlet at the vents, carrying with it in its passage the molten material to form the solid cone.

An Explosion (?) upon the Sun.—The following interesting account of a very unusual disturbance upon the sun, from the pen of Prof. C. A. Young, will shortly appear in the *Boston Journal of Chemistry*, from advanced sheets of which we print it in full.

On the 7th of September, between half past twelve and two P. M., there occurred an outburst of solar energy remarkable for its sudden-

*Neues Jahrbuch für Mineralogie, 1871, p. 469.

ness and violence. Just at noon the writer had been examining with the telespectroscope* an enormous protuberance of hydrogen cloud on the eastern limb of the sun.

It had remained with very little change since the preceding day—a long, low, quiet looking cloud, not very dense or brilliant, nor in any way remarkable except for its size. It was made up mostly of filaments nearly horizontal, and floated above the chromosphere† with its lower surface at a height of some 15,000 miles, but was connected to it, as is usually the case, by three or four vertical columns brighter and more active than the rest. Lockyer compares such masses to a banyan grove. In length it measures 3′ 45″, and in elevation about 2′ to its upper surface—that is, since at the sun's distance 1″ equals 450 miles nearly, it was about 100,000 miles long by 54,000 high.

At 12.30, when I was called away for a few minutes, there was no indication of what was about to happen, except that one of the connecting stems at the southern extremity of the cloud had grown considerably brighter, and was curiously bent to one side; and near the base of another at the northern end a little brilliant lump had developed itself, shaped much like a summer thunder-head.

What was my surprise, then, on returning in less than half an hour (at 12.55), to find that in the meantime the whole thing had been literally blown to shreds by some inconceivable uprush from beneath. In place of the quiet cloud I had left, the air, if I may use the expression, was filled with flying *débris*—a mass of detached vertical fusiform filaments, each from 10″ to 30″ long by 2″ or 3″ wide, brighter and closer together where the pillars had formerly stood, and rapidly ascending.

When I first looked some of them had already reached a height of nearly 4′ (100,000 miles), and while I watched them they rose with a motion almost perceptible to the eye, until in ten minutes (1.05) the uppermost were more than 200,000 miles above the solar surface. This was ascertained by careful measurement; the mean of three closely accordant determinations gave 7′ 49″ as the extreme altitude attained, and I am particular in the statement because, so far as I

*This is the name given to the combination of astronomical telescope and spectroscope.

† The *chromosphere*, (called also *sierra* by Proctor and others) is the layer of hydrogen and other gases which surrounds the sun to a depth of about 5,000 miles. Of this the prominences are mere extensions.

know, chromospheric matter (*red hydrogen* in this case) has never before been observed at an altitude exceeding 5′. The velocity of ascent also, 166 miles per second, is considerably greater than anything hitherto recorded.

As the filaments rose they gradually faded away like a dissolving cloud, and at 1.15 only a few filmy wisps, with some brighter streamers low down near the chromosphere, remained to mark the place.

But in the meanwhile the little "thunder head," before alluded to, had grown and developed wonderfully, into a mass of rolling and ever-changing flame, to speak according to appearances. First it was crowded down, as it were, along the solar surface; later it rose almost pyramidally 50,000 miles in height; then its summit was drawn out into long filaments and threads which were most curiously rolled backwards and downwards, like the volutes of an Ionic capital; and finally it faded away, and by 2.30 had vanished like the other.

The whole phenomenon suggested most forcibly the idea of an *explosion* under the great prominence, acting mainly upwards, but also in all directions outwards, and then after an interval followed by a corresponding inrush; and it seems far from impossible that the mysterious coronal streamers, if they turn out to be truly solar, as now seems likely, may find their origin and explanation in such events.

The same afternoon a portion of the chromosphere on the opposite (western) limb of the sun was for several hours in a state of unusual brilliance and excitement, and showed in the spectrum more than 120 bright lines whose position was determined and catalogued,—all that I had ever seen before, and some 15 or 20 besides.

Whether the fine Aurora Borealis which succeeded in the evening was really the earth's response to this magnificent outburst of the sun is perhaps uncertain, but the coincidence is at least suggestive, and may easily become something more if, as I somewhat confidently expect to learn, the Greenwich magnetic record indicates a disturbance precisely simultaneous with the solar explosion.

C. A. Young.

Dartmouth College, September, 1871.

On the Origin of Life.—The address of Sir William Thompson, to the British Association, is in everything relating to physics a most masterly review of the present condition of science, from one who is a recognized leader in modern scientific thought and research. It is therefore with considerable surprise, after so thorough and ex-

haustive an exposition of the state of knowledge in those branches, that we read his concluding sentences upon the origin of life on the earth. Utterly repudiating, as unworthy of credence, the doctrine of spontaneous generation, so vigorously maintained in our own times by Pasteur, Pouchet and Bastian, he suggests the following curious substitute, for the paternity of which his claim, we are inclined to believe, will never be disputed.

Referring to the case of a volcanic island, suddenly emerging from the sea, and becoming in a few years clothed with vegetation through the agency of seeds transported to it from the sea and air, he inquires whether it may not be possible, or even probable, that the beginning of vegetable life upon the earth may be explained in a similar manner. Every year millions of fragments of solid matter—meteoric stones—fall upon the earth, and he conceives that these foreign visitants may be the fragments of worlds beyond ours, scattered in every direction through space, by collision with another, bearing upon them seeds, living animals and plants, which might be deposited, still endowed with life, wherever they may chance to find a final resting place. "The hypothesis," he continues, "that life originated on this earth through moss-grown fragments from the ruins of another world, may seem wild and visionary; all I maintain is that it is not unscientific."

With the alternative before them of accepting the views of the learned physicist, it would scarcely prove a subject of surprise to hear that the advocates of spontaneous generation refuse to be moved from their position.

Nitrate of Silver and Charcoal.—Dr. Chandler* communicates the following interesting item, in connection with the materials above named:—When solid nitrate of silver is placed upon glowing charcoal, deflagration takes place, the result being that the silver is left behind in the metallic state. The curious phenomenon attending the reaction is that the nitrate, being fused by the heat of the chemical action, sinks down into the pores of the coal, and as each particle of the latter is replaced by the reduced silver, the structure of the original wood is retained.

Dr. C. states that he has succeeded in this way in producing masses of silver weighing an ounce or more, which show most beautifully the rings of annual growth in the wood. The author directs that a crystal of the nitrate be placed on the end of a stick of charcoal, and the

* American Chemist, September, 1871.

blowpipe flame directed upon the coal beside it to start the reaction. As soon as the deflagration sets in, crystal after crystal may be added.

A New Mode of Preparing a Common Reagent.*—Mr. John Galletly communicates the fact that a mixture of equal parts of sulphur and paraffin (or with a larger proportion of sulphur) when heated in a flask to a temperature not much above the melting point of the sulphur, will evolve sulphuretted hydrogen with great steadiness. The author recommends the process as the most convenient of any yet devised for laboratory use. Where a pound of the material is used in a suitable generating vessel, the evolution of gas may be prolonged for several days with great regularity. The production of the reagent can be stopped and renewed at pleasure by withdrawng or applying the lamp.

New Gas Forge.—The American Chemist contains the description of an apparatus of this kind, having the following construction: There is claimed for it a degree of heating power, sufficient to fuse bronze, copper, gold and silver. The principle is that of the Bunsen burner, (in which the burning gas is mixed with a supply of air before combustion), but differs from the ordinary burner in having the openings through which the gas enters some distance above those supplying the air. Encircling the tube through which the mixture passes is an outer tube, open above and below, by which an additional supply of air is furnished to the flame, and the draught is increased.

Phosphorus Bronze.—In connection with the item mentioned in our last issue, it may be in place to add, that experiments are at present being made in France, upon an extensive scale, to test the value of the addition of small quantities of phosphorus to various alloys of copper and zinc, especially in relation to the manufacture of bronze guns, in the construction of which especial advantages are claimed for these alloys.

Selenitic Mortar.—Col. Scott, R. E., has lately invented a process of producing mortar which is asserted to possess decided advantages.

The peculiarity of the process consists in mixing with the water used a small quantity of gypsum or plaster-of-Paris, or by adding green vitriol. The mixture is made in the pan of an ordinary mor-

* Chem. News. xxiv, 162.

tar mill, the water and gypsum being first introduced, and then the lime. After grinding the lime for a short time, the sand, burnt clay, or other materials are added, and the whole mass is ground for ten minutes longer. By this process, it is said a cement-mortar can be obtained which sets quickly, and can be used for concrete, bricklayers' work &c., cheaper than the ordinary material. Tests made with this mortar against Portland cement—under the same conditions—gave a result in favor of the former, the breaking weights of the two materials being 156 lbs. (mortar) and 58 lbs. (cement).

Statistics of Population.—The following curious calculation is extracted from a letter received from a well-known engineer. It may prove of interest to our readers.

* * * * * * * * *

Sir John F. W. Herschell, in a foot note pp. 455 and 456 of "Familiar Lectures on Scientific Subjects" (Alexander Strahan & Co., London, 1866), says: For the benefit of those who discuss the subject of population, war, pestilence, famine, etc., it may be as well to mention, that the number of human beings living at the end of the hundredth generation, commencing rom a single pair, doubling at each generation (say in thirty years) and allowing for each man, woman and child, an average space of four feet in length, and one foot square, would form a verticle column, having for its base the whole surface of the earth and sea spread out into a plain, and for its height 3674 times the sun's distance from the earth. The number of human strata thus piled one on the other, would amount to 460,790,000,000,-000. So far Mr. Herschell. In attempting to verify his figures, I find, according to those last above quoted, that he calls the sun's distance from the earth 95,000,000 miles.

This is too much according to recent determinations. It is now set down (see The Sun. Richard A. Proctor, London, Longmann, Green & Co, 1871, p. 64) at about 92,000,000 miles, equal to 485,760,000,000 *feet*, equal to 121,440,000,000 *strata* of four feet each in the sun's distance from the earth. J. C. HOADLEY.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By Prof. J. E. Nourse.

(Continued from page 167.)

Disposition of the Colonies after obtaining Independence.

In the history of the plans for communication between the two seas, Mexico and the Central American States appear in somewhat enviable contrast with their old masters. The persistently stupid mandates of the Spanish Court had consigned the idea of an open route to *official* oblivion. They could not blot it for one moment from the minds of the merchant or the statesman.

Two remarkable eras had indeed existed, at each of which either Spanish or British power might, at least, have effected vast improvements in the miserable highways from the Pacific, over which the jaded animals of the trains plodded with their treasures. At each of these eras the full scheme was broached of an open navigation. It was listened to, approved, talked of, and dropped by the men in power. To detain a few moments in memory of these eras will not be profitless.

The first was at the close of the seventeenth century. It was the seemingly romantic but wise plan of William Paterson, the founder of the Bank of England. He conceived the idea of securing for his countrymen, the Scotch, an independent colonial establishment in Darien, in which they could reap the gains of trade from both oceans. He wanted for them and for the English some share in the marvelous returns realized by such companies as the Dutch East India Co., the English E. I. Company being then unformed. To establish such a colony, became the ruling idea of his life. "This object," says a late biographer who revives well earned tributes to Paterson's memory, "merited the praise given it in the last century, of being calculated to improve the policy of all civilized States in the Western Hemisphere; and the important events of *the present day in the same regions*, bring out his genius as a statesman in the most brilliant light." ("Paterson's Writings, Bannister; London, 1859.")

The attractive details of his scheme; his voyage to Darien—touching at the New York of 1698; his establishment of a colony of 1200

stalwart Scotch who, but for their and his pacific purposes, might have overturned Spanish rule in America; the support of his company by capitalists in London, Hamburg and Amsterdam, despite the opposition of the Dutch East India Co.; the vaccillating policy of the English King ending in neglect, and finally in cruel opposition; and the end of the colony at Caledonia after Campbell's heroic resistance to the Spanish fleet; are matters of strange history. It is known that the lamented Warburton was on the very journey to Darien, to work up these exploits of that land into a historic romance, when he perished on the ill-fated Amazon in 1852.

Sir John Dalrymple's Memoirs of Gt. Britain and Ireland, 1790, give us Paterson's true aims. "This door of the Seas and key of the Universe—Darien"—says Paterson, "with anything of a reasonable management, will enable its proprietors to give laws to both oceans without being liable to the fatigues, expenses and dangers of contracting the guilt and blood of Alexander and Cæsar."

There is a further passage in one of Paterson's letters which seems so prophetic of America that we cannot pass it by. "But if neither Britain singly, nor the maritime ports of Europe will treat for Darien, the period is not very distant when instead of waiting for the slow returns of trade, America will seize the pass of Darien. Their next move will be to hold the Sandwich Islands. Stationed thus in the middle, on the east, and on the west sides of the New World, the English Americans will form the most potent and singular Empire that has appeared, because it will consist not in the dominion of a part of the land of the globe, but in the dominion of the whole ocean. They can make the tour of the Indian and Southern Seas, collecting wealth by trade wherever they pass. During European wars they may have the carrying trade of all. If blest with letters and arts, they will spread civilization over the universe. Then England, with all her liberties and glory, may be known only as Egypt is now."

Reading these words of Paterson's, we are tempted to ask why, but for English blindness and folly, was this colony—the pride of Scotland, the whole population of whose city, Leith, turned out to see it embark—why was it so cruelly opposed and killed by the home and foreign authorities of England? And why, in our day, but for some suicidal blindness of our own land bringing about this sad decay of the American marine, is not America already ruling, as predicted, both oceans? And why shall we not now pursue until successful the opening up of a navigable transit from sea to sea, which shall aid in recovering our destined supremacy in commerce?

Pass we *one century* forward strangely enough to find the other era in the far past in which something hopeful seemed to dawn on the prospect of intercommunication across Central America. It was the era of the proposed emancipation of these States in 1797. In that year proposals were offered by Genl. Miranda, of New Grenada, and by Commissioners from Mexico and other States to Mr. Pitt, the sixth article of which stipulated "the opening of the navigation between the Atlantic and Pacific oceans, through Panama and through Nicaragua."

Mr. Pitt entered into the scheme promptly and cordially. Miranda wrote most hopefully of it to Alexander Hamilton. The plan asked also of the United States 10,000 troops, to aid in emancipating the Colonists from Spain, the British Government agreeing to find the ships and money. But President Adams following, doubtless, Washington's well-known policy of non intervention, declined an immediate answer, and the measures were postponed. The scheme is not cited here as having contained good ground of expecting to secure then a full interoceanic transit, since the progress of that age had not secured the necessary engineering skill, power, or facilities. The historic era is, however, worth nothing.

It was then that the Edinburg *Review* sufficiently appreciated the idea of a navigable passage across the Isthmus, to write in bold terms thus: "This is the mightiest event, probably, in favor of the peaceful intercourse of nations which the physical circumstances of the globe present to the enterprise of man. It is the same thing as if, by some great revolution of the globe, our eastern possessions were brought near us. Immense would be the traffic which would immediately begin to cover that ocean, by denomination, Pacific. * * * *China and Japan*, brought so much nearer European civilization, would not be able to resist the salutary impression, but would soon receive *important changes in ideas*, arts and manners."—*Edinburg Review*, vol. xiii.

As these words are quoted to-day, the presence before the writer of more than twenty young Japanese curiously engaged in their inquiries at the National Institutions of Washington, the remembrance that tons of American works on education have been sent from the United States to Japan, and that an invited Commission of some of our chief citizens is now on its way to benefit that Empire in agricultural pursuits,—forcibly seal the prophecy of the reviewer, that important changes of ideas would come over the Asiatics. But they

are those of American, not of European civilization. They are the influence of the very people who, the cruelly treated Patterson foresaw, would become potent.

They have become potent by the genius of men little dreamed of by the Edinburg reviewer—by inventions and works not within his range of vision—by the printing press of Franklin, the steamboat of Fulton, the telegraph of Morse—by the energy and endurance of the Tottens, and Stephens, and Hoadleys and Huntingtons, who have already twice spanned the continent with a Western Railroad.

But it is full time that we come back,—hopeful of the reader's indulgence,—to the chronicle of the American Republics in relation to interoceanic transits. The governments of Central America, so far as at any time they have been dignified with the name, have often shown a very favorable disposition towards the opening of transits from sea to sea. Notwithstanding the difficulties incident to their protracted struggle for freedom, and their new and unsettled political and social condition, they seem to have opened the door to enterprise; have encouraged applications for permissions to explore and survey the routes; have lent a ready ear to the propositions of capitalists and even of adventurers in this field. Fuller notices of this more properly connect themselves with brief narratives to be given of each of the routes. Suffice it here to say that the great Humboldt obtained from Gen. Bolivar, the "*Liberator*," "the Geodesic survey of the Isthmus of Panama;" that in 1837–'38 lake Nicaragua, and the river San Juan and the isthmus lying between the lake and the port, were surveyed by Bailey at the request of Gen. Morazan, then President of the Republic; that in 1842, under the Presidency of Santa Anna, Garay's survey was made by Moro and others across Tehuantepec; that in the same year urgent solicitations were made by leading men in Central America through Castellon, to the late Emperor of France, urging him to come over and personally undertake the work of a ship canal across lake Nicaragua, a proposition previously laid before the King of Holland; that within the last ten years very many sincere advances have been made, and propositions from capitalists and corporations have been readily accepted, and charters thereupon issued by the several Central American States towards the execution of the great work, the ship canal, as well as the less important works of railroads across from sea to sea. The British Vice-Consul at Panama, in 1865, tells us that in the spring of that year, "applications were presented

to the Congress of Bogota by two companies and three firms for the privilege of cutting a canal." It is stated, in the able report on this subject of interoceanic communication, made in 1839 to the U. S. House of Representatives by the Chairman on roads and canals, Hon. C. Fenton Mercer, that while the states of S. America, "exhausted by their struggle for independence and by internal commotions, could not be expected to undertake such works without foreign capital, they have demonstrated their sense of its importance, and have shown a readiness to receive aid from foreign nations, manifesting a disposition to waive, for the welfare of mankind, every narrow and local interest."

To this it may be added that the patience of these governments has been sometimes tried, and their just expectations disappointed when they have cordially and equitably made grants to individuals and companies, professing to obtain them for the opening of some important route. The New Granadian Minister Plenipotentiary to the French Court in 1860, thus wrote to a French company undertaking an exploration: "Commence by exploring in Darien, for there you have ground for hope; you need not fear to spend money there, for the maritime canal is possible nowhere else. * * *

"*My government has reason to be weary of granting* concessions of mines and lands to persons who look for nothing from the grants but some *immediate* money-making scheme. These concessions change hands; no one regards the terms, and so the non-suiting of the parties and foreclosing of the contract is usually the end of the matter."

CHRONICLE OF EFFORTS TO SECURE INTEROCEANIC TRANSITS.

Instructions of Charles V. to Cortez, 1534; Antonelli sent by Philip II. to explore Nicaragua; three routes urged by Gomara, 1554; Paterson's "Four passes," 1701; proposals by citizens of Oaxaca, 1715; Tehuantepec route explored by Cramer, 1774; exploration of the San Juan by Galisteo, 1781; Miranda's proposals to William Pitt, 1797; decree of Span. Cortez for canal across Tehuantepec, 1814; surveys under Bolivar, 1827; Holland company formed, 1830; Mission of Col. Biddle, 1836; Bailey's survey of Nicaragua, 1838; proposals to Louis Napoleon, 1840; Garay's survey of Tehuantepec, 1842; Garella's survey of Panama route, 1843; Dr. Cullen's explorations, 1849; William's survey of Tehuantepec, 1850–51; Child's survey of Nicaragua, 1851; Panama R. Road, 1855; survey of Honduras route, by Squier, 1854, by Trautwaine, 1858; Lt. Strain's, Gisborne's and Prevost's crossing of Darien, 1854; surveys of the Atrato Route for Kelley, 1853–55; Lt. Michlel and Lt. Craven's survey of the Atrato, 1858; Bourdiol's expedition, 1861; Pim's expedition, 1864; De Puydt, 1865; Lacharme and Flachat, 1866; Commander Selfridge, Darien, 1869—71; Capt. Schufeldt, Tehuantepec, 1870.

(To be continued.)

A FEW ADDITIONAL FACTS IN RELATION TO THE TESTING OF THECAPACITY OF BOILERS.

By S. L. Wiegand.

The fact of the writer of this communication appearing as a participant in a report rendered to the parties pecuniarily interested in a test of boilers, described to the Institute at the monthly meeting in January last, and published in the March number of the *Journal*, seems a sufficient warrant for stating some additional facts in relation to the conditions under which the test was made.

The prime object of the investigation of the power of boilers appears to be to satisfy or dissatisfy the purchasers of steam boilers with their purchases.

Having had the opportunity of observing that the endeavor is being made to procure for the method of testing boilers above referred to, the sanction and approval of this Institute, an opportunity is desired to submit all the facts of that test.

All questions involved between the sellers and the purchasers having been settled and finally adjusted, and the results having been published, there can be no impropriety in submitting all of the facts of the case to the Institute and the public.

Two boilers of the pattern known as double tank were erected in separate and contiguous furnaces, each boiler having 500 feet of heating surface and 16 square feet of grate surface.

The steam from these boilers passed into two pipes of six inches diameter and five feet in length, and thence, through 28 feet of pipe 4 inches in diameter, into a steam drum 14 feet long and 30 inches in diameter, and thence, through a pipe 4 inches in diameter and 12 feet long, to the engine. All of the pipes and drum were unprotected by clothing, and in well-ventilated apartments.

The engine has been correctly described as 4 feet stroke and 16 inches bore of cylinder.

The proper speed of the engine was 55 revolutions per minute. The cylinder of the engine was covered with a lagging of black walnut, one inch thick, leaving an air space of two inches between the lagging and cylinder.

The slide valve was so proportioned and adjusted as to admit steam to the cylinder the moment the crank passed the centres, and to close in the last two inches of the stroke.

The exhaust opened at the last half inch of the stroke, and remained open until the last half inch of the returning stroke.

When the boilers were erected the Tremper cut-off was placed as close to the steam-chest as it was possible to have it, and there appeared to be no difficulty for some time in maintaining the speed of the engine at 55 revolutions, and in keeping the steam blowing off at the safety valves, which were set at 120 lbs. per sq. in. Whilst supplying steam to a 500 lb. Morrison hammer, a pressure of 100 lbs. per sq. in. was adequate to maintain the speed at 55 revolutions, and diagrams showing 88-horse-power have been taken by a McNaught indicator at that speed.

When the engine was running at its proper speed, the initial pressure of steam in the cylinders was always from 15 to 17 lbs. less than that of the boiler.

There was not enough work or resistance upon the engine to show larger diagrams, although the steam could be kept blowing off.

The McNaught indicator, as being unreliable (for reasons not explained), and the writer, owing to a presumption of being an interested party, were objected to by a disinterested engineering firm, and upon their suggestion Mr. Brown was engaged to take diagrams with a Richard's indicator.

A difficulty arose in feeding the boilers. The water was pumped from an open heater (that is, a heater in which the feed-water is showered in a vessel forming part of the exhaust-pipe and in contact with the exhaust steam, condensing a portion of it) by a plunge pump operated by the engine.

The same man acted both as engineer and fireman.

A change of engines was made, and it became difficult to run all the machinery and maintain the speed and steam pressure.

The engineer left his situation without notice, and the Tremper governor was found to be broken so as to be entirely inoperative.

The purchasers of the boiler expressed doubts as to the boiler being capable of developing 100-horse-power collectively.

A Throttle governor (Shive's) was applied, and a test by indicator was demanded by the purchaser.

The slide-valve remained in the adjustment, that has already been described.

An accident, maiming a workman entangled in a belt on the main line shaft of the factory, interrupted the discussion, and prevented such a test.

The makers of the boiler refused to be bound by any test so made. A Tremper governor was then applied, with a short pipe intervening between the cut-off valve and steam-chest.

The tests described were then made.

It was objected by the writer that the steam pipe and steam drums should be protected from radiation, and that the entire draught of the chimney should be used for the boiler, there being at the time an open ing into the flue which was imperfectly closed by a damper that had been warped by heat.

The purchasers declared that, unless a test was made then and under the existing conditions, they would replace the boilers with others.

The makers, having no choice but to submit to the test or have the boilers removed without test, concluded to submit to the test.

The purchasers declined to allow the boilers to be fired by the man who had first run them successfully.

A fireman was engaged from a neighboring mill, who worked to the best of his ability.

The diagrams as exhibited to the Institute are correct representations of those drawn by the instrument on that occasion. The calculations of the diagrams are believed by the writer to have been correctly made.

After the test had been concluded the makers, at their own cost, furnished the purchasers an additional boiler of such size as to furnish the complement of 100-horse-power, by the rating obtained from the diagrams in the test.

The writer would respectfully submit that such a mode of testing exhibits not the full capacity of the boiler, but is vitiated by the infirmities of the steam connection, the defects of draft, and quality of fuel.

Since the erection of the additional boiler, the pipes and steam drum have been covered with non-conducting material, the defect in the water supply remedied, the apertures leading from the boiler to the steam pipe increased in both number and size, and the work upon the engine greatly augmented. Complete satisfaction with the performance of the boiler is expressed by the purchasers.

The test above referred to has been cited in evidence in a case now in litigation, with a view to prove that another boiler sold by the same party, differently proportioned and constructed, had not the power which the purchaser expected to realize.

There is not, so far as the knowledge of the writer extends, any necessity for measuring the capacity of a boiler by a steam engine; and, since the same quantity of steam may be made by expansion to develop more than twice the dynamic effect that is possible without expansion, there does not seem to be any proper inducement to have recourse to such a mode of measuring.

Another plan has been pursued which, when the boiler is capable of slightly superheating the steam, avoids the objection to that by the indicator. It consists in measuring the feed-water, and noting the temperature of it, and in maintaining a uniform pressure of steam, and observing to maintain the temperature of steam above that indicated by Reynold's table for saturated steam of that pressure.

To institute any just comparison of evaporative capacity between different boilers, it is believed the following conditions should be stated, and, if practicable, made equal: the grate surface, the heat absorbing surface, the quality and size of fuel, the quantity of air consumed in a given time, the temperature of the feed-water, the temperature and pressure of the steam generated.

For a comparative test of economy, the following data would seem requisite:

The quantity of fuel consumed to evaporate a given quantity of water, the cost of the boilers relatively to their evaporating capacity.

Any difficulty about the correct expression of the result can be easily avoided by stating it in known and established measures, as in lbs. or in cubic inches, instead of attempting to convert it into an expression of horse-power.

It would be well to determine with definite exactness, where and how the power is to be measured, if it be in foot pounds and must be expressed in horse powers, without expansion at the boiler.

Dr. Ure tells us, in the supplement of his dictionary, that 900 cubic inches of water converted into steam, afford 1,980,000 ft. lbs., which, if converted into the usual standard of horse power and time, is one horse power for one hour.

Now, if the steam be used expansively, the dynamic effect may be more than doubled. Should the makers of boilers be compelled to adapt their operations to meet the requirements of the best practice in engine construction, or the worst, or what intermediate class of works?

So far as avoiding disappointment to some purchasers is concerned, it has so far been beyond the ability of any boilers makers.

There are men who employ steam power who frankly say that they have no faith in indicator diagrams, and that they don't consider that they have derived any power from their boilers until it has passed into the driving band, and begins to do the work they want it for. In short, they believe the piston duty of an engine, as shown by indicator diagrams, may represent a great deal of power wasted in the engine itself.

How must such men be satisfied?

Is it not sufficient, after accurately describing to the purchaser the boiler in all its parts and dimensions which it is proposed to make for him, and delivering the boiler exactly as described, to warrant the conclusion that the seller has been just to the buyer, without engaging in the presumption of a contract to furnish horses power for the determination of which, as yet, no definite method has been established, and which, if established, must be empirical?

It may be objected, that business men, in buying boilers, may be misled by reason of not understanding steam engineering, and that some protection should be afforded them in such matters. But they have at command the same protection in that matter that others have when engaging in operations which they do not understand. They can employ the skill that they themselves have not.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Concluded from page 248.)

Veneers.

Veneered surfaces in wood-work, although unpopular to some extent as a "sham," have many claims that are overlooked by those that are not acquainted with the operation of veneering, and do not consider the matter mechanically. By the use of veneers we are able to construct on cabinet work with surfaces of the beautiful and variegated, crotch, motley or birds-eye wood, which it would be impossible to use unless glued to a "ground" of some more stable and trustworthy material, for in wood, as in many other things in nature, the plainer the appearance the greater the merit. The strength of wood as well as its tendency to "warp" or "spring," is, as a rule, determined by the regularity and straightness of the grain, and such wood as makes the most beautiful veneers is in the same degree use-

Wood-working Machinery, Plate IX.

Jour. Frank. Inst., Vol. LXII.

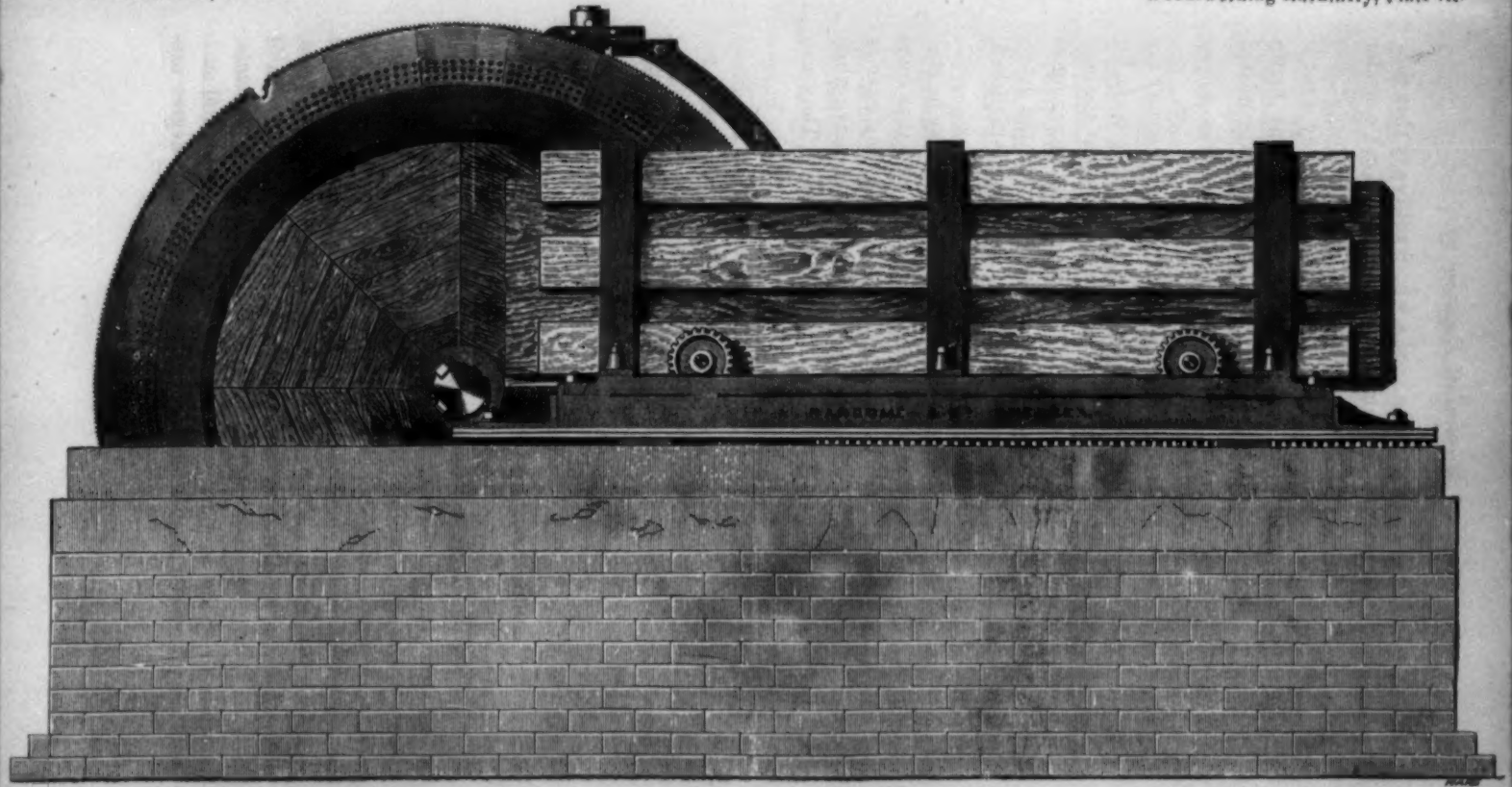


Fig. 1.

less for any other purpose than ornamentation. In short, wood work cannot be both handsome and strong if made from solid material; hence the system of veneering.

Veneers are usually laid on a backing of good dry pine; the most reliable and cheap are in our American markets. It not only "stands" well when seasoned, but is sufficiently porous to give a good glue surface, without which veneers are liable to peel off with age or dampness. To "lay" veneering in a proper and reliable manner, not only requires skill on the part of the workmen, but calls for a sound judgment of many conditions, which, if not carefully considered, ends in failure.

The porosity of the wood must first be considered with reference to the amount of glue that will be absorbed—whether the surfaces shall be "sized" to fill the pores, and if so, to what extent; also what the consistency of the "sizing" shall be. The natural temperature and consistency of the glue and the amount to be laid on, are all questions involving nice discrimination. The veneers themselves must also be considered. Some kinds of wood, such as American walnut, will not permit of dampening or steaming unless there is quite a regularity of fibre. The veneers known as crotch wood (from the forks of trees) in which the grain is disposed at all angles in the same piece, has to be laid without dampening, or it will crack when dry; but plain wood, such as rosewood, motley wood, or bird's-eye, can be dampened, which greatly facilitates the process of laying. In this country, previous to the employment of machinery, and when furniture was made by hand, veneers were laid by "cauls," and hand-screws, or "rubbed on," the first plan being adopted for all surfaces of any considerable size, while the narrow bands of two inches or less in width were rubbed on. The caul is simply a thin board coated with beeswax, to prevent the adhesion of glue; it is heated and placed between successive layers of veneered pieces, communicating its heat through the veneers and melting the glue, when the whole is compressed with screws. A very common error in laying veneers with cauls, is to use the glue too hot, or to warm the stuff to be veneered, which requires just the opposite treatment to that of the caul; to be kept cool and allow the glue to chill as soon as possible, this prevents evaporation of the water from the glue, which, when again melted by the hot caul, returns to the same condition in which it left the glue pot.

It is best when practicable to expose the glue surface to the cold air, even in winter, as fast as the glue is laid on, and while the cauls

are being prepared. The rubbing process requires no little dexterity, and in the shops is considered a good test of the workman's abilities, the veneers being cut into strips and jointed, the wood surface being sized, dried and scraped.

The veneer is wet on the outside with a sponge dipped in hot water; the glue, which must be very thick and hot, is then hastily applied to the other side; the veneers then placed and rubbed down with the "pane" of the veneer-hammer before the "glue sets," the whole requiring the greatest dexterity and skill.

The writer of this article does not in his mechanical experience remember anything that was approached with the same trepidation as the first attempt to rub down veneers.

Veneers are manufactured by sawing and by cutting. The sawed veneers, being the best, command a much higher price in the market, a distinction that would be necessary even if the quality was the same, the "waste" being greater than the "product." Thirty-five to the inch is a common gauge for sawed veneers of mahogany, the saw kerf being nearly twice as much.

In cutting or shaving veneers with a knife there is but little waste; the wood is, however, somewhat fractured by the cutter, which must of necessity have an obtuse angle at its edge to secure strength.

We present in this number, engravings of two veneer cutting machines, as manufactured by Messrs. Ransome & Co., of London, England.

Fig. 1 is a sawing machine in true side elevation, $\frac{1}{2}'' = 1'$. The log is fastened to the frame or carriage seen in the fore ground, and is automatically fed to the saw by means of screws that regulate the thickness, which, as a minimum, is thirteen to the inch, including kerf.

The saws are made from eight to fourteen feet diameter, the weight of the machines being from six to twelve tons. The saws make from one to two hundred revolutions per minute.

The peculiarity of veneer sawing mills is entirely with the saw, which consist generally of a cast iron disc turned up with great truth. The saws, which are in sections, are riveted to the periphery, and are ground off to a very thin edge; the veneer, being thin and flexible, bends outward to accommodate this wedge-form of the saw and cast-iron disc, obviating the necessity of setting the saw and facilitating the cutting by giving clearance for the dust and plate.

Fig. 2 is a side view, on the same scale, of a veneer slicing or cutting machine, by the same makers.

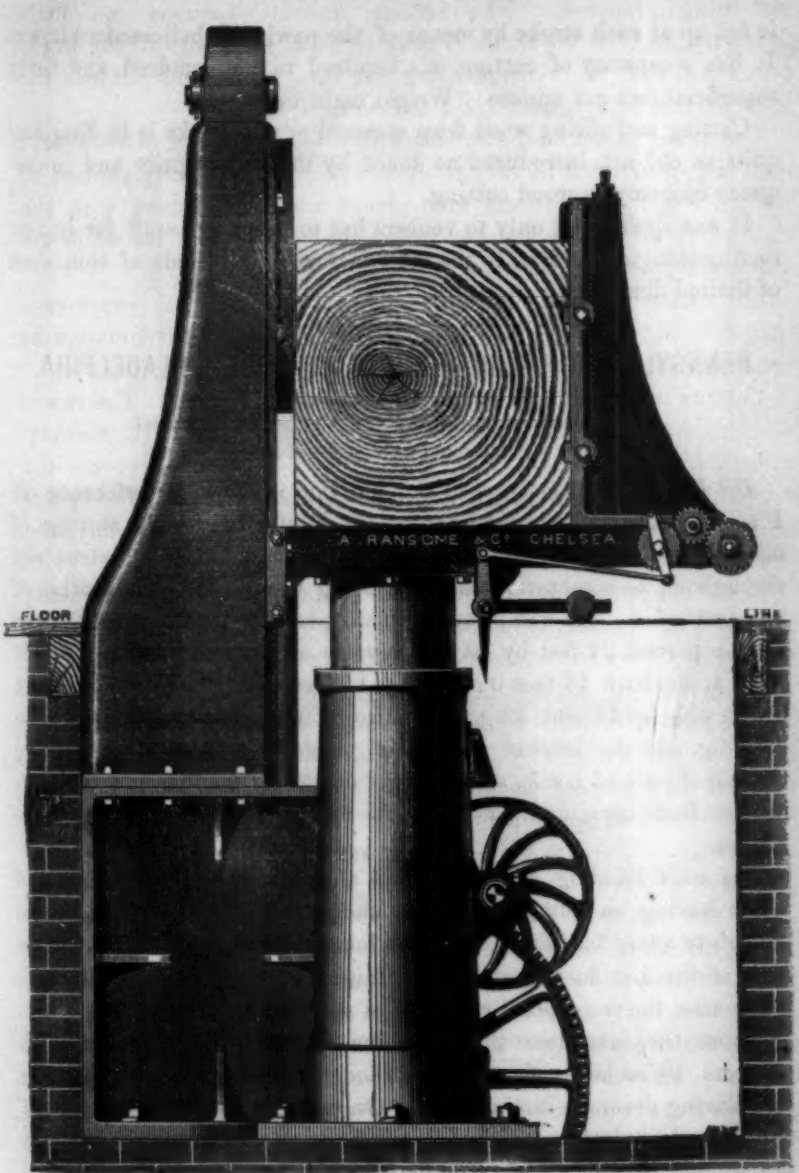


Fig. 2.

The knife is stationary, supported by the strong column on the right; the platen on which the wood is mounted has a reciprocating vertical movement to correspond with the depth of the "stick," which

is fed up at each stroke by means of the pawl and bellcranks shown. It has a capacity of cutting one hundred to one hundred and forty superficial feet per minute. Weight eight tons.

Cutting and slicing wood from steamed or wet blocks is in England quite an old art, introduced no doubt by the higher price and consequent economy in wood cutting.

It was applied not only to veneers but to preparing stuff for boxes, roofing-shingles, in fact, to the manufacture of all kinds of thin stuff of limited dimensions.

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.
P. A. Engineer Construction Department Pennsylvania Railroad.

(Continued from page 114.)

Oil House. The location of this building is shown by reference to Plate I, where it is marked No. 5. It is intended for the storage of oil for use in the shops, and is designed as a fire-proof structure throughout, no combustible material being used in the construction of any part of it. As will be seen by the plan, Plate XI, it consists of a main portion 24 feet by 30 feet, outside measurement, with a boiler room at the back 13 feet 6 inches by 13 feet, and a platform in front 6 feet wide by 14 feet long. A railroad track runs in front of the building, and the level of the top of platform is made 4 feet above the top of rails of track, a convenient height for loading and unloading oil from cars, and our standard height of platform for warehouses.

The main building is divided into a first floor and basement, the latter having an outside entrance under the front platform, wide enough to admit barrels of oil. The foundations and walls, up to the level of the first floor, are of stone finished off with a cut stone belting course, the front platform being of stone also.

Above the first floor the walls are of brick 9 inches thick, with pilasters 13 inches. The basement floor is of brick laid in cement and having drainage into a sewer. On each side of a passage way 7 feet wide, low platforms of brick are built on flat brick arches, for the support of oil tanks. The first floor is supported through the centre by two cast iron columns sustaining wrought iron I beams, from which spring flat brick arches. The cast columns are of ½ inch metal, 8 inches external diameter at the top and 4 inches at the bottom, and rest upon firm stone foundations. The wrought iron I beams are

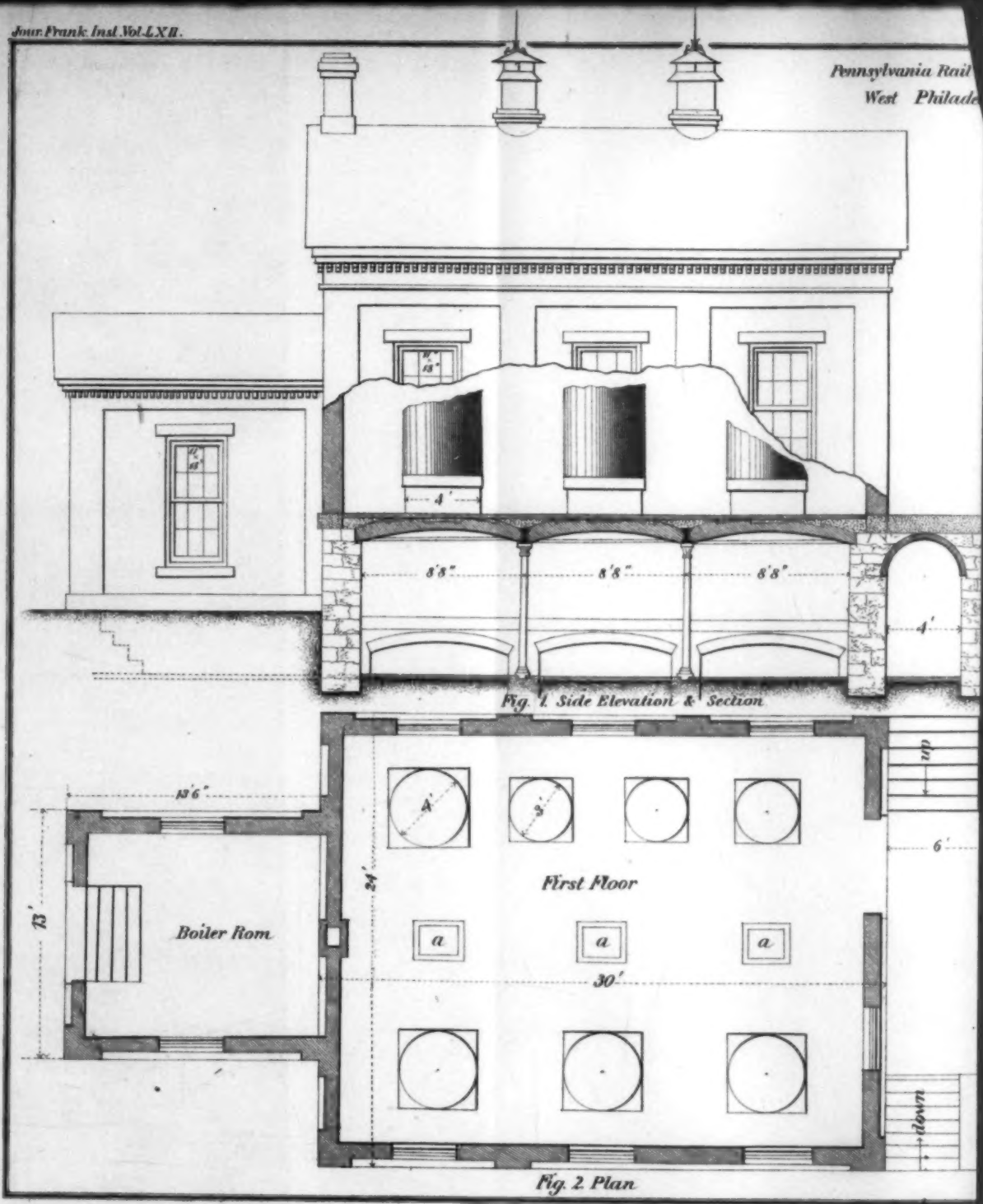


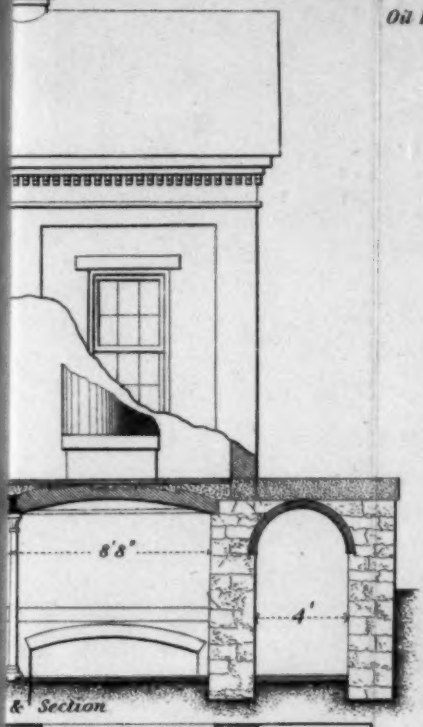
Fig. 1. Side Elevation & Section

Fig. 2. Plan

Jas McGregor, Lith. Phila.

Pennsylvania Rail Road Shops
West Philadelphia.

Oil House.



& Section

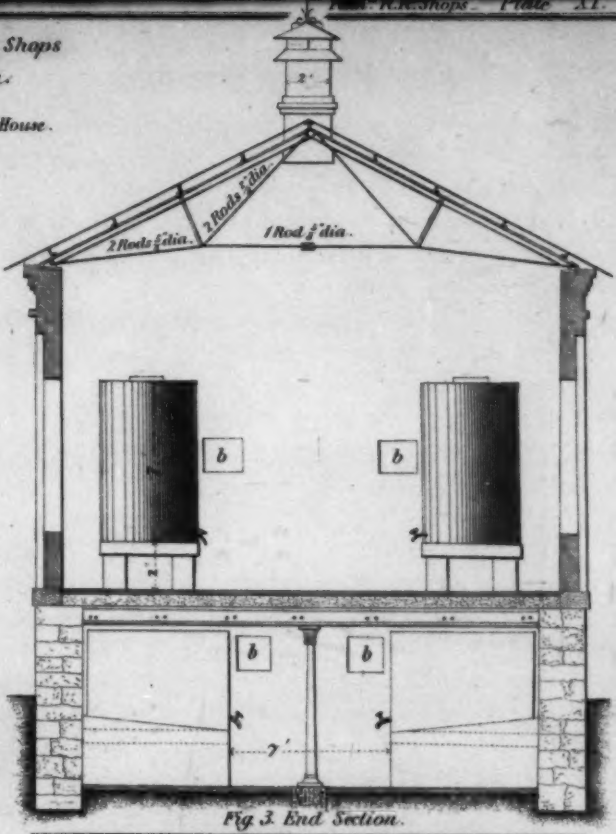
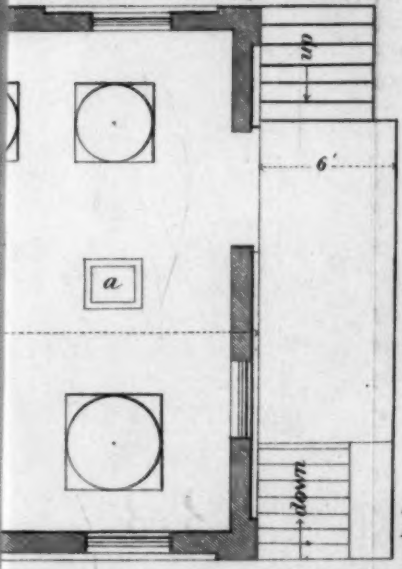


Fig. 3. End Section.



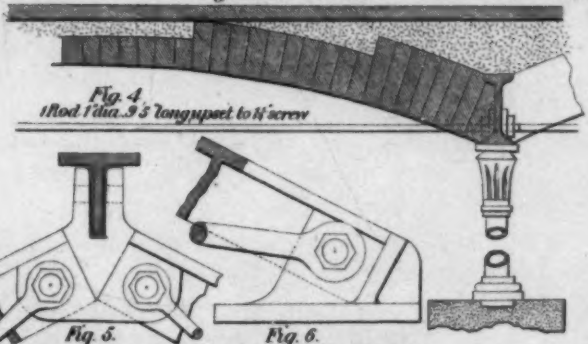


Fig. 4
1 Rod 1" dia. 9'5" long upset to 1½" screw

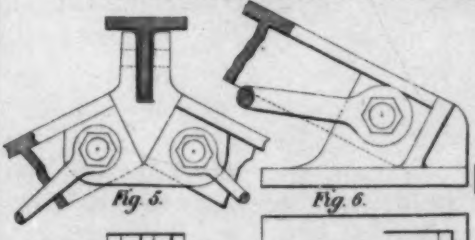
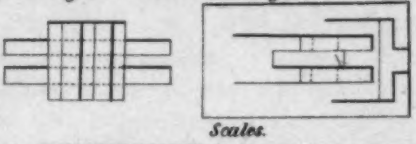


Fig. 5. Fig. 6.



Scales.

Fig. 123. Feet.
Fig. 4. Feet
Fig. 5.6. Inches.

Construction Dep.t Penn.a R.R.

Jas McGeagan lith. Phila.

Feet.
Feet.
Inches.

Rep.t Penn.a R.R.

9 inches deep, weighing 89 pounds to the yard, and they are connected together, and also to 4-inch angle irons on the end walls, at distances of 3 feet apart in their lengths, by iron rods 1 inch in diameter, these rods taking and counteracting the thrust of the brick arches which spring from the I beams and angle irons. On top, the arches are leveled off with concrete and paved with brick, thus forming the first floor. Fig. 4, Plate XI gives the details of these arches.

Brick piers supporting stone slabs, are built on the first floor in the positions shown on plan, for the support of oil tanks, the top surface of stone being 2 feet above the floor. The basement is lighted by openings in the crown of each arch of the ceiling, marked *a*, in the plan, and filled with hammered glass 1 inch thick. The first floor has ample light from seven windows, the frames and sash of which are of cast iron, and outside shutters of wrought iron. The doors are of wrought iron, with frames of cast iron. The roof is a simple wrought iron truss, the rafter being 3½ by 3½-inch T iron, the ridge pole of the same, and the purlines of 3-inch angle iron. The number and sizes of the tie rods are given on the Plate, and Figs. 5 and 6 show details of head and heel blocks, which are of cast iron. A covering of corrugated galvanized iron, with two large ventilators to carry off the disagreeable odors of the oil, completes the building.

To provide light at night and to prevent taking any fire into the oil rooms, four small windows, one light each, 18 inches square, of heavy glass set permanently into an iron frame, are built into the wall between the main portion of the building and the boiler room, see *b* on Plate, and a gas burner is placed before each window on the boiler room side, so as to shine into the main building when lighted. Vertical pieces of 4-inch cast iron pipe are built in the arches of the first floor over openings in each tank of the basement, to allow basement tanks to be easily filled from the oil room above, and also to afford facilities for the introduction of pumps to transfer the oil from these tanks to tanks on the first floor.

The boiler room is provided with a small vertical boiler, working at a low pressure (only the ordinary pressure in the service water pipes) and having coils of steam pipe in the basement and on first floor for warming in winter.

The basement tanks are rectangular in form, with an inclined bottom, being so made that any sediment may collect in front and be easily removed, when necessary, through an opening provided for the purpose. There are three of these tanks on one side and four on the

other, the large tanks holding 1739 gallons, one smaller one 1618 gallons, and the remaining three 1130 gallons each. On the first floor are four large tanks, cylindrical in form, of 642 gallons each, and three smaller tanks of 361 gallons each. The total capacity of tanks is 13876 gallons, or 385½ barrels. The tanks are constructed of boiler iron. Should it be needed, a mixer can easily be put up on the first floor, and be heated by a steam coil from the boiler. The mixing, however, is now done at Altoona oil house, a larger building than this, but constructed upon the same general plan.

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 91.)

"Good new belt leather has been found to break with an average tension of 5000 lbs. applied quietly per square inch of sectional area.

"The working tension for continuous service ought not to be more than about one-fourteenth of this, or about 350 lbs. per square inch.

"A thickness of three-sixteenths of an inch, which is the ordinary thickness, equals ·186 inch; therefore, for an inch of breadth we have ·186 × 5000 = 930 lbs. breaking strain, and ·186 × 350 = 65·1 lbs. continuous service strain.

"With the same working tension, when we double the breadth, we reduce the strain per square inch of section to one-half the strain for the single breadth, and thereby save the belt. The axle pressure is the same, however, because the belt of double breadth is simply doing the same amount of work upon the rim of the pulley as the single breadth had to perform.

"When we double the diameter, the revolutions of pulley per minute being as before, we may reduce the tension to one-half; because we have the speed at the circumference equal to 2, and this multiplied by ·5 tension = 1 power; the same as 1 speed × 1 tension = 1 power.

"When two pulleys at rest are connected by a belt the tension on each connecting part is nearly equal; when motion begins, the driving pulley has to stretch the pulling parts to the tension required to overcome the resistance before the driven or loaded pulley can move; and, in doing so, the driver is passing a corresponding amount of slack into the returning part.

"Should the resistance of the load grow less from any cause, less tension will be required to balance it, and the driven pulley will be moved by the excess of the pulling tension a fractional quantity faster than the driver, thereby throwing part of the slack of the returning part into the pulling part, until the reduced load resistance and the pulling tension come to a balance; this diminishes the amount of slack on the returning part.

"On the other hand, should the load increase from any cause, greater tension is required; the driver must move a fractional quantity more than the loaded pulley to put the greater strain upon the belt, and the amount of slack is increased correspondingly.

"Hence, in a narrow belt, the returning part will be slacker than when a broader belt is employed, because it will stretch more with a given tension.

"Short belts require to be tighter than long ones. A long belt, working horizontally, increases the tension by its own weight, acting in the curve formed between the pulleys.

"One of the properties of this curve is to make the tension greater than is due to the simple weight of the belt; that is greater than when the belt is hanging vertically; besides it never loses contact.

"In vertical belts so little stretch is needed to make them lose contact with the lower pulley, that the tension for the state of rest requires to be greater than is found necessary for a horizontal belt, if the breadth be not increased to reduce the stretching stress per sectional square inch.

"In ordinary leather belts, on large pulleys, the bending resistance is so small that it may be disregarded.

"Ropes of hemp or wire are often employed for driving bands. Their resistance to bending is greater than that of flat leather belts, and as the surface in contact with the pulling is less, the pressure per square inch of actual contact must be greater, and therefore more severe upon the material.

"This, however, does not affect the amount of tension required for work, because, as friction is independent of the extent of surface, we get the same driving power from 10 lbs. pressure or tension on the narrow line of contact with the pulley in the case of a circular rope, that we would get from the same pressure supposing the rope flattened out so as to have a surface of contact many times greater.

"When we know the weight per foot of a long belt or rope working horizontally, we find the tension in the curve of the belt between

the pulleys by multiplying the whole weight of the part between the pulleys by the distance between the same and dividing by eight times the deflexion. This rule, however, applies only to curves in which the deflexion is small compared with the span; so that the flatter the angle of suspension the closer the approximation."—*Power in Motion.* By J. Armour, C. E. Lockwood & Co., London, 1871.

Mr. C. R. Rossman, in the *Technologist* for Oct., 1871, gives 45 lbs. per inch of width as the safe working tension of single leather belts, and presents the following data: A 125 horse engine drives two 18-inch belts over 8-foot pulleys, making 75 revolutions per minute. This gives a velocity of 1875 feet per minute, and a tension of 61 lbs. to the inch of belt.

"This is in excess of the safe limit of tension generally recommended; but we may here remark that belts of the width here mentioned are generally thicker and stronger than the average belts used, and from which the ordinary data were taken. But, from a careful examination of a great number of cases of belts of ordinary width and strength, we find that a safe and judicious limit lies between 40 and 50 lbs. In order to increase this, however, it is not unusual for engineers to double the thickness of the belt by cementing or riveting two thicknesses of leather together. But this plan, though advisable in some cases, is not so economical of power and material as the equally efficient plan of increasing the width of the belt."

"The tensile strength of good ox-hide, well tanned, has been carefully examined, with the following results:

The solid leather will sustain, per inch of width,			675	lbs.
At the rivet holes of the splices	"	"	382	"
At the lacing	"	"	210	"
Safe working tension	"	"	45	"

The belts are assumed to be one-fifth of an inch thick."

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 262.)

At the surface and five feet below, the floats give a less velocity than the meter; a light wind was blowing up stream at the time, which would probably retard the floats a little. Below this point, the floats show a greater velocity than the meter, constantly increasing towards the bottom. Making the difference at the surface zero, a

slightly curved line will pass through nearly all the points of difference. The ordinates of this line are given in the last column of the table, headed "Corrected Difference." The observed differences and this curve are plotted in Plate II, figure 6.

TABLE V.

No. of Observations.	Wind, parallel to the direction of the river, in miles per hour.	Depth of observation below the surface.	Velocity of Current in feet per second.			Corrected Difference.
			By Floats.	By Meter.	Difference.	
50	3·26 up	1 ft.	3·619	3·655	—0·036	
62	1·92 "	5 "	3·759	3.783	—0·024	0·030
56	1·27 "	10 "	3·703	3·674	+0·029	0·070
50	0·48 "	15 "	3·590	3·516	+0·074	0·120
54	0·29 down	20 "	3·598	3·405	+0·193	0·170
31	0·53 up	25 "	3·637	3·441	+0·196	0·240
37	0·80 "	30 "	3·546	3·279	+0·267	0·320
29	2·18 down	35 "	3·556	3·166	+0·390	0·400
12	4·85 "	40 "	3·636	3·142	+0·494	0·490
7	0·74 up	45 "	3·542	2·985	+0·557	0·600

1st. The Error of Cross Section.

In order to ascertain the true mean area, it would be necessary to know the exact depth of the river past the whole base line. Generally it is considered sufficient to sound out two or three lines across the river, and take their mean. But when the bottom is not perfectly regular, this may differ considerably from the true mean depth. It is claimed that one reason why so short a base was chosen in the Mississippi observations, was that the eddies, whorls, and common irregularities of the current, past a long base, vitiated the results; and Mr. S. F. Abbert, who made some current observations with double floats on the Arkansas River in 1869, shortened his base to 100 feet, because he found too much irregularity in 200. Then, if the base is reduced to zero, all errors from this cause must disappear, which is precisely what is done when meter observations are made.

However, on Gen. Abbert's suggestion, this matter was tested on the St. Clair River. The base was divided into three nearly equal parts, and floats were located and timed past each section.

It was found that, though individual floats varied greatly, the mean velocity in each section was about the same as the mean velocity past the whole base.

2d. The Pulsation of the Current.

This is, perhaps, the most curious phenomenon of flowing water

All water in motion, from the jet of a toy fountain to the Gulf stream, has an intermittent velocity, increasing and diminishing in accordance with some yet undiscovered law. This fact has been known for a long time; but without some such apparatus as the telegraphic meter, the amount and duration of these pulsations, especially below the surface, could not be measured. With this meter, however, by placing a Morse's paper register or, better, a chronograph in the circuit, every revolution of the wheel can be recorded on the moving paper, and thus every change in the velocity of the current noted.

Although these pulsations were found in every stream that was tried, from the slow-moving St. Lawrence to the tail race of a mill, no general law of variation has yet been deduced, and we can only say that the lesser fluctuations are from half a minute to a minute in duration, with larger ones every five or ten minutes.

They do not seem to be synchronous with the oscillations of the surface level, which are also very irregular, and attain their maximum fully as often during the increase as the decrease of the velocity.

Nor can M. Bazin's supposition be correct, that they are due to eddies and whorls of the surface current, as they are much smaller at the surface than toward the bottom. In fact, as near the bottom as measurements could be made, the velocity was sometimes less than half what it was at its maximum.

Capt. Boileau, speaking of the belief of Dubuat and other engineers of the adherence of the fluid molecules in contact with the bottom, says:* "But it would seem more rational, and more in accordance with experiments, to consider the bottom and sides as forming by their asperities eddies, which consume nearly all the work of the motive forces, so as to leave the force of translation very weak. On the other hand, we know that each eddy formed in a fluid current causes, by the lateral communication of its movement, a second, of greater size but with less force of rotation, and this gives birth to a third, still more feeble, and so on until these gyratory movements become insensible."

The formation of ridges in the sand at the bottom of canals, as shown by Dubuat's experiments, in precisely the same manner as the sand dunes are formed by a pulsating wind, would seem to indicate also the existence of such eddies at the bottom, which would of course

* Traité de la mesure des eaux courantes. Par P. Boileau. Paris, 1854. Page 339.

produce variations in the velocity of the current, decreasing towards the surface, just as the observations show is the case with those pulsations.

But, whatever theory be accepted as to their cause, it is easy to see that they must greatly affect the velocity obtained from floats, particularly as we approach the bottom.

Often, when two floats were put out from the upper boat, one minute apart, the last one would gain upon and sometimes even pass the first. As 150 floats is a good day's work, if we assume that each float is one second in passing the centre foot of the base line where the mean area is taken, the velocity will have been actually measured for only 150 seconds during the day, and the mean would be greater or less than the true mean velocity, according as the majority of the floats had passed during the increase or decrease of the pulsations.

3d. The Uncertainty of Location.

Even when the base line was one-third the width of the river, and the stations connected by telegraph, it was found almost impossible to locate the exact point where the float crossed the section lines. As the velocity is slower near the banks, the measured velocity would be too small or too large, as the location was on one side or the other of the true place of the float. Moreover, the floats rarely ran parallel to each other, or in the same vertical plane.

Often, in still weather, when the upper boat was in the center of one of the 200 feet divisions (into which the rivers were divided by imaginary lines for convenience in reduction), part of the floats would run entirely out of the division, or more than 100 feet out of their proper plane. The calculated path of the float was sometimes more than half a foot in a hundred longer than the distance between the section lines.

4th. Floating Bodies Move Faster than the Water in which they are Immersed.

This error is very small compared with the others, and the formula for its computation has already been given.

5th. The Upper Float Drags the Lower.

This error is also small, and depends upon the relative size of the floats and the velocity of the current.

6TH. THE EFFECT OF THE CURRENT ON THE CONNECTING CORD.

The cord used in the Mississippi observations was from one to two-tenths of an inch in diameter. It has a tendency to drag the lower float; but, what is of more importance, it can never be perfectly straight, but curves down stream, and therefore raises the lower float. This brings the float into a faster current, and thus gives much too large velocities, especially when the depth is considerable.

When starting the floats from the upper boat, both cannot be thrown out together without danger of entangling the cord; but the upper must be held until the lower has gone far enough to extend the cord. The upper float must then move enough faster than the lower to assume its proper position before they reach the upper section line, otherwise it will pass the base with nearly the full velocity of the surface current, instead of being retarded by the lower float. Whether this actually takes place cannot be known; and the distance required for the two floats to assume their proper relative positions will depend on the length of the connecting cord and their velocity.

When the floats are in their proper relative position one cannot be vertically over the other, but the cord must form a curve, whose chord is the hypothenuse of a right-angled triangle, the perpendicular being the actual depth of the lower float, and the base varying according to the depth, velocity and relative size of the floats and the length and size of the connecting cord.

Of these errors the first three are uncertain, and the last three are always plus; but the sixth is the most important, as well as the most difficult to eliminate. It is, however, evident that these errors must increase with the depth, as the comparisons given in Table V show, the lowest observation giving the error of floats over half a foot per second. This correction would only apply to float observations in a river of the same depth and velocity as the St. Clair. In the St. Lawrence, with a current of only about one mile an hour, it is much less. In the deep and swift-flowing Mississippi it must be much greater. The discharge, computed from the meter observations, was about ten per cent. less than that obtained from the floats; and we may therefore call the co-efficient of double floats, when observed past a long base, 0·9. When a shorter base is used, the errors of observation would probably somewhat decrease this co-efficient.

MAXIMUM VELOCITY.

About the year 1730 Pitot invented the tube which has since borne

Table VI.

Series.	Form of Canal.	Character of Bottom.	Width.	Depth.	Ratio of Depth to Width.	Mean Velocity.	Depth of maximum Velocity below surface.
			Meters.	Meters.		Meters.	
59—1	Rectangular	Plank	1·988	0·084	0·04	1·207	
62—1	"	Strips 0·01 m. apart	1·988	0·129	0·05	0·961	
59—2	"	"	1·994	0·134	0·07	1·573	
65—1	"	" 0·05 m. apart	1·992	0·135	0·07	0·756	
58—1	"	Plank	1·998	0·138	0·07	0·730	
63—1	"	" 0·01 m. apart	"	0·144	0·07	1·454	
62—2	"	"	"	0·158	0·08	1·336	
61—1	"	"	"	0·160	0·08	0·643	
60—1	"	Plank	1·994	0·180	0·09	2·297	
59—3	"	"	"	0·201	0·10	2·501	
65—2	"	" 0·05 m. apart	1·992	0·207	0·10	1·000	
58—2	"	Plank	1·998	0·215	0·11	0·953	
63—2	"	" 0·01 m. apart	"	0·218	0·11	1·925	
61—2	"	Plank	"	0·244	0·12	0·854	
62—3	"	" 0·01 m. apart	"	0·248	0·12	1·702	
68—1	Trapezoidal	Plank	1·500	0·191	0·13	0·908	
69—1	"	"	1·048	0·133	0·13	0·406	
59—4	Rectangular	"	1·984	0·265	0·13	2·318	
67—1	"	" 0·05 m. apart	0·800	0·110	0·14	1·084	
63—3	"	" 0·01 m. apart	1·988	0·286	0·14	2·199	
66—1	"	" 0·05 m. apart	1·994	0·288	0·14	1·464	
55—1	"	Cement	1·812	0·269	0·15	2·569	
65—3	"	" 0·05 m. apart	1·992	0·312	0·16	1·295	
62—4	"	" 0·01 m. apart	1·998	0·320	0·16	1·979	
58—3	"	Plank	"	0·332	0·17	1·248	
61—3	"	" 0·01 m. apart	"	0·377	0·19	1·109	
66—2	"	" 0·05 m. apart	1·994	0·380	0·19	1·675	
68—2	Trapezoidal	Plank	1·580	0·300	0·19	1·188	
69—2	"	"	1·148	0·221	0·20	1·771	
58—4	Rectangular	"	1·988	0·436	0·22	1·429	0·030
65—4	"	" 0·05 m. apart	1·992	0·412	0·22	1·511	0·130
69—3	Trapezoidal	Plank	1·208	0·275	0·23	1·992	
68—3	"	"	1·800	0·433	0·24	1·329	
64—1	Rectangular	" 0·01 m. apart	1·988	0·487	0·24	0·856	0·157
56—1	"	Gravel	1·832	0·394	0·24	1·714	
57—1	"	Small stones	1·860	0·452	0·25	1·471	0·050
61—4	"	" 0·01 m. apart	1·988	0·495	0·25	1·267	0·155
73—1	Semicircular	Plank	1·100	0·270	0·25	0·966	
71—1	"	Cement	1·000	0·268	0·27	1·052	
69—4	Trapezoidal	Plank	1·281	0·342	0·27	2·156	
68—4	"	"	1·984	0·540	0·27	1·497	0·190
72—1	Semicircular	Fine Sand	1·006	0·292	0·29	0·954	
69—5	Trapezoidal	Plank	1·348	0·393	0·30	2·281	
73—2	Semicircular	"	1·260	0·377	0·30	1·230	
74—1	"	Small stones	1·080	0·327	0·31	0·825	
69—6	Trapezoidal	Plank	1·398	0·430	0·31	2·385	0·130
64—2	Rectangular	" 0·01 m apart	1·988	0·660	0·33	0·948	0·230
71—2	Semicircular	Cement	1·160	0·378	0·33	1·300	
72—2	"	Fine sand	1·165	0·388	0·33	1·266	
71—3	"	Cement	1·180	0·456	0·39	1·534	
74—2	"	Gravel	1·170	0·458	0·39	1·028	0·120
73—3	"	Plank	1·300	0·554	0·41	1·450	0·110
72—3	"	Fine sand	1·190	0·488	0·41	1·392	
71—4	"	Cement	1·200	0·528	0·44	1·676	

TABLE VI.—*Continued.*

Series.	Form of Canal.	Character of Bottom.	Width.	Depth.	Ratio of Depth to Width.	Mean Velocity.	Depth of maximum Velocity below surface.
			Meters.	Meters.		Meters.	
72—4	Semicircular	Fine sand	1·210	0·554	0·46	1·569	
74—3	"	Gravel	1·200	0·567	0·47	1·162	0·160
70—1	Triangular	Plank	0·800	0·380	0·47	1·406	
71—5	Semicircular	Cement	1·225	0·588	0·48	1·782	
70—5	Rectangular	Plank	1·400	0·686	0 49	2·218	0·130
70—3	"	"	1 160	0·570	0·49	1·922	0·130
70—2	Triangular	"	0 980	0·480	0·49	1·719	0·130
70—6	"	"	1·480	0·735	0·49	2 294	0·130
71—2	Semicircular	Cement	1·250	0·625	0 50	1·786	0 100
73—4	"	Plank	1·400	0·704	0·50	1·162	0·050
74—4	"	Small stones	1·220	0·610	0·50	1·229	0·200
70—4	Triangular	Plank	1·260	0·630	0·50	2 084	0 130
71—8	Semicircular	Cement	1·250	0·632	0·51	1·810	
71—7	"	"	"	0 662	0·53	1·786	
72—5	"	Fine sand	"	"	0·53	1·679	0·050
67—3	Rectangular	Plank	0·800	0·486	0·61	1·860	0·156

SMALL FEEDERS IN MASONRY.

75—1	Trapezoidal	Masonry	1·201	0·150	0·13	1·824	
75—2	"	"	1·203	0·234	0·19	2 352	
75—3	"	"	1·204	0·291	0·24	2·560	
75—4	"	"	2·750	0·464	0·29	2·707	
76—1	Irregular Trapezoid	"	2·750	0·464	0·16	0·266	
76—2	"	"	3·000	0·623	0·21	0·391	0·303
76—3	"	"	3·200	0·746	0·23	0·461	0·453
76—4	"	"	3·400	0·835	0·25	0·513	0·400
77—1	"	"	1·996	0·663	0·33	0·253	0·203
77—2	"	"	2·060	0·853	0·42	0·413	0·500
77—3	"	"	2·080	0·987	0·47	0·501	0·500
77—4	"	"	2·100	1·135	0·54	0·638	0·650

his name, and made the first actual measurements of the subsurface velocity of water in canals. Before that time many engineers held, with Castelli, that the velocity of the molecules of water increased directly as the depth, while others, following Guglielmini, believed the increase was the square of the depth. None doubted, however, that the maximum velocity was at the bottom, although Papin warned his contemporaries against attempting to apply to fluids Galileo's laws for the friction of solid bodies.

Pitot's experiments proved that the velocity in canals increased for a certain distance below the surface, and then decreased toward the bottom.

Since his time many observations have been made to determine the law of variation in the velocity, with apparently very diverse results. Most of these observations were made on small canals, and in them the maximum velocity was found considerably below the surface; while in the few European rivers and streams which have been gauged, it was at or near the surface. The latest velocity observations on canals are those made by MM. Darcy and Bazin; and, as they give their observations in detail, we can readily find the *locus* of maximum velocity. Table VI is compiled from their observations.* It shows the kind of canal used, the nature of the bottom, the width and depth of the water, the ratio of the width to the depth, and the distance below the surface of the maximum velocity of the center vertical.

The descent of the maximum velocity in these observations does not seem to depend on the velocity, but upon the ratio of the depth to width, and somewhat upon the character of the bed. Thus, in rectangular canals the maximum of the center vertical remains at the surface until the depth is about one-fourth the width; but when the depth is half the width it descends to about one-third the depth below the surface.

In triangular canals, on the other hand, the surface velocity is the greatest until the depth is about one-third the width; and when this ratio is one-half, the maximum is only about one-fifth the depth below the surface.

In the trapezoidal and semicircular canals, the portion of the sides enclosing the water is slanting until its depth is about one-half the actual depth of the canal; then it becomes vertical, or nearly so; so that below that point the effect is the same as in the triangular, and above it, the same as in the rectangular canals.

* Récherches Hydrauliques, page 187 *et seq.*

The nature of the bed seems to have an influence upon the descent of the maximum velocity, for when the lining of the canal was rough the table shows it to be somewhat deeper than when the lining was smooth.

This table only gives the *locus* of the maximum velocity of the center vertical. In the rectangular canals it is often found at mid depth near the sides, even when the ratio of depth to width is small enough to carry it to the surface on the center vertical. Thus, lines drawn through the points of equal velocity follow nearly parallel to the bottom and sides of the retangular canals, until about mid depth, when they bend inwards toward the center, as if forced off from the upper portion of the vertical sides.

In the canals of other forms this effect is not so marked, and in the triangular is scarcely noticeable.

M. Bazin remarks that the friction of the air has certainly much less influence in retarding the upper layers of the water than this curious and unexplained influence of the sides.

(To be continued.)

New Illuminating Devices.—Mr. R. Brown has devised a safety-lamp especially adapted for giving increased illumination over the ordinary forms. The lower part of the wire-gauze cage is furnished with a plano-convex lens, which is surrounded by a cone of tin plate, which serves to protect the glass and increase the reflection. The light is additionally increased by the use of a reflector behind the flame.

Mr. T. E. Rome has likewise invented a signal lamp, which shall relight itself automically (a Relume signal-lamp). The construction, which is ingenious, is as follows: A compound rod or bar—composed of two metal strips of different co-efficients of expansion is fixed above the flame and a catch attached to the end of the bar is held in place while the lamp is burning. So soon as the lamp is extinguished, the bar, which is bent or curved by the unequal expansion of its two sides from the heat of the flame, begins to cool and to straighten. When quite straight the catch is removed, liberating a spring which causes some matches to be ignited and to light a second wick.

Mechanics, Physics and Chemistry.

THE CHEMICAL THEORY OF THE VOLTAIC BATTERY.

By Joseph P. Cooke, Jr.

MOLECULES AND ATOMS.

1. *Fundamental Laws.*—Within the last ten years two important principles have become almost universally recognized as fundamental laws of chemistry. These are:

First, that *The molecules of matter, when in the state of gas, and under like conditions of temperature and pressure, occupy in all cases the same volume.*

Secondly, that *The atoms of matter have different degrees of quantivalence, measured by the rate at which they replace or combine with each other.*

2. *Molecules.*—Molecules are the smallest particles of any substance which can exist of themselves, and the first law enables us to estimate their relative weight. For, if equal volumes of all substances (under the conditions named) contain the same number of molecules, it is obvious that the weights of the molecules must be in every case proportional to the weights of the equal gas volumes of the substances compared; or, in other words, proportional to the specific gravities of these substances in the state of gas. Hence, if we selected hydrogen—the lightest gas—as the standard of specific gravity, and the hydrogen molecule—the lightest molecule—as the standard of molecular weight, the number which expresses the specific gravity of any gas would also express its molecular weight.

Our modern chemistry, however, while adopting hydrogen gas as the standard to which it refers the specific gravities of gases, has found it more convenient to take the half hydrogen molecule (the hydrogen atom) as the unit of molecular weight; so that the molecular weight of any substance, on this system, is equal to twice its specific gravity in state of gas, referred always to hydrogen gas as the standard.

The law we are considering is generally known in Germany as the Law of Avogadro, and it will be convenient to refer to it under this name; but it must be remembered that although we owe to Avogadro

the present form of statement, yet the fundamental facts on which the law is based were discovered by Gay-Lussac, and the principle itself distinctly enunciated by Ampére many years previously. The law of Avogadro is simply the law of Gay-Lussac, concerning the combination of gases by volume, as interpreted by the modern chemical philosophy.

If this law has been established, then the molecular weights are equally well-established facts of science, as fully so, for example, as the weights of the planets. These last are inferences from the law of gravitation, just as the molecular weights are inferences from the law of Avogadro. It is true that our knowledge of the molecular weights is limited to their relative values; but the same is almost equally true of our knowledge of the planetary weights. The earth is the standard to which the planetary weights are referred; and, while our knowledge of these weights in terms of the earth's mass is very accurate, it is only by indirect and, at best, approximate methods that we can refer this astronomical standard of weight to our ordinary units, the kilogramme or the pound. Nevertheless, although it would be highly satisfactory to know the exact weight of the planets in *pounds*, yet all the important purposes of astronomy are subserved so long as we know their weight in *earths*, the standard itself, from its very magnitude, being quite beyond the limits of our clear conceptions.

Now, the hydrogen atom, selected as the unit of molecular weights, is just as definite a mass of matter as the earth, and this chemical unit of weight lies no further beyond the range of our conceptions on the one side than does the astronomical unit on the other. Moreover, although we cannot be said to know the weight of this unit in fractions of a grain, the considerations advanced by Sir William Thompson, in a recent paper,* gives us reason to believe that the discovery of the relation between the two is at least within the range of possibilities. But, even if the constant required for reducing the molecular weights to their metrical values was known, it would add but little to our available knowledge in regard to them. Even in the ordinary affairs of life, we are always more concerned with relative than with absolute weights; and to how few persons does the term grain or gramme convey any definite conception of quantity.

A part of the vagueness of the conception which attaches to the

* American Journal of Science and Arts, July, 1870.

idea of molecular weight arises undoubtedly from the want of a specific name to designate the unit; and, since the word crith has already been used to denote the weight of one litre of hydrogen, I would propose to call the weight of one hydrogen atom (the chemical unit of weight) a microcrith. When we speak of the oxygen molecule as weighing 32 microcriths, this name will help to convey the impression that we are dealing with definite and measurable quantities.

It will undoubtedly be asked, how has the equality of the molecular volumes been proved? for, as we have seen, our knowledge of the molecular weights, and indeed the whole philosophy of modern chemistry, rests on the truth of this assumption. The question cannot be answered in a few words, for this great law of chemistry, like the law of gravitation, is an induction based on a great body of facts. It is true that, if certain postulates are granted, the law of Avogadro can be shown to be the necessary consequence;* but the proof of its validity is to be found rather in the circumstance that it not only coordinates the great body of known facts, but also is constantly leading to new discoveries. There are still discrepancies to be explained, but these are being one by one cleared up, and there can be no doubt that this law rests on as firm a basis to-day as did the law of gravitation for a half century after it was first enunciated by Newton.

3. *Atoms.*—Avogadro's law has not only given us clear conceptions in regard to the *molecules* of matter and their relations, but in connection with the doctrine of chemical quantivalence it has also led to an equally clear conception of the relations of *atoms*. *An atom*, as defined by modern chemistry, *is the smallest mass of an elementary substance that exists in any molecule.* Take, for example, the many volatile compounds of oxygen which are known. By determining their specific gravities in the state of gas, we can find the several weights of their respective molecules. In each case, by doubling the number expressing the specific gravity of the gas—referred to hydrogen—we obtain the weight of its molecule in microcriths. By chemical analysis we learn what proportion of the whole mass, and therefore what proportion of each of these molecules, is oxygen. Now, it appears that the smallest quantity of oxygen in the molecule of any known substance weighs 16 microcriths. Hence, 16 microcriths is

* See two remarkable papers on this very point, by Alex. Naumann and Karl Zöppritz, in the Annalen der Chemie und Pharmacie, vii, Supplement Band Seiten 339 and 348.

the weight of the oxygen atom. Further, it appears that a molecule of oxygen gas weighs 32 microcriths. The molecule of this elementary substance consists, therefore, of two atoms. We do not assert that this mass of matter we call the oxygen atom is indivisible, but, simply, that it has never been, to our knowledge, divided; or, in other words, that it is the smallest known mass of the elementary substance. Should we hereafter discover an oxygen compound whose molecule contained only 8 microcriths of the elementary substance, then the atomic weight of oxygen would be at once reduced to one-half of its present value.

It must be evident from what has been said that this conception of the atom involves no further assumption than the truth of Avogadro's law, and that the atomic weights are as definite values and rest on the same basis as the molecular weights.* But these legitimate inferences have been overlaid by a conception which, although very generally adopted by chemists, must be regarded as a pure hypothesis. We must necessarily view the molecules as isolated masses of matter, as much so as the planets, but according to this hypothesis the atoms are also distinct monads, pre-existing as such in the molecule, which is simply an aggregate of atoms. A chemical change consists, then, in the breaking up of the molecules, and the rearrangement of these parts, which merely shift their position, and retain their identity throughout all the molecular transformations. Those who hold this theory would expect, could they apply sufficient magnifying power, to see in each molecule of water, for example, three distinct particles, two of hydrogen and one of oxygen. Such an idea, however, is not a necessary part of the legitimate atomic theory, for it is certainly equally conceivable that the molecule of water would appear perfectly homogeneous, and that in the process of chemical decomposition the resulting oxygen and hydrogen molecules are evolved from the water by a much more subtile operation than the mere re-arranging of pre-existing particles. For it must be remembered that the various qualities which distinguish substances may depend, not on the essential nature of individual monads, but on divers affections superinduced on the same material substratum.

It is undoubtedly true that the common conception of the chemical

* For a further discussion of this subject, and other methods by which the molecular weights even of non-volatile substances may be frequently indirectly determined, see the author's work on Chemical Philosophy. Sever & Francis, Cambridge, 1869.

atom harmonizes with the only explanation we have as yet been able to give of a very large number of facts, and this is especially true of those phenomena which are to be considered in this paper; but we cannot be too careful in distinguishing between the legitimate inferences from established laws, and hypotheses, which, however convenient as aids to the attainment of general truths, that in their essense are still incomprehensible, must be regarded at the best as crude and mechanical ideals.

The atoms, then, of our modern chemistry, whether we regard them as pre-existing as such in the molecules, or as in some unknown way evolved from the molecules in the chemical process are real not ideal, magnitudes. They are quantities of matter, whose weight in microcriths is definitely known, and whose relations have been carefully studied. This study has led to the discovery of the law of quantivalence, the second of the two great laws enunciated above.

4. *Quantivalence.* According to the old chemical philosophy the atoms were equivalent, in the sense that they could replace each other, unit for unit, in a compound body. Hence on this system the atomic weights were the same numbers as the so-called chemical equivalents, and the two numbers were essentially synonymous. But when the atom is defined as above such is not the case, and the new philosophy distinguishes different orders of atoms, which it designates as univalent, bivalent, trivalent, quadrivalent, &c., according as they have the power of replacing one, two, three, four or more atoms of the lowest order, or an equivalent number of atoms of a higher order. Moroever the quantivalence of an atom measures not only its replacing but also its combining or "atom-fixing" power; for every atom can combine with or attach to itself as many atoms of either kind as it can replace, provided, of course, such combination is otherwise possible.

The doctrine of quantivalence opens at once the study of molecular structure, for on the multivalence of one or more of its atoms depends the stability of every complex molecule, and no molecule can exist as an integral unit unless its parts are all bound together by these atomic clamps. By studying the reactions by which molecules are formed or transformed, we have been able, in many cases, to discover the order in which the atoms are united in these microcosms, and the field of investigation thus opened is one of the most fruitful and most attractive which chemistry now presents. To those who have not carefully followed the progress of the work during the last

ten years, the results which are claimed may appear incredible, but, however great the skepticism in relation to the subject, any one who candidly and thoroughly examines the evidence can hardly fail to be convinced that the knowledge of molecular structure already reached is positive and real.*

As is well known, the atoms of many of the elements have different degrees of quantivalence, and it has been urged that this fact renders the whole doctrine indefinite and unsatisfactory. Now, it must be admitted, that with our present imperfect knowledge of the subject matter of chemistry, there is necessarily a certain amount of obscurity about all the generalizations of the science. But, without entering upon a detail of the facts on which the doctrine is based, and by which alone it can be justified, it is sufficient to say in reply to the above objection, that a change in the quantivalence of an atom implies not only a fundamental change in the qualities of the compounds into which it enters as a radical, but also a fundamental change in all the chemical relations of that radical itself. Such differences as those between the ferrous and ferric compounds of iron are familiar to every chemist, and the relations of the ferrous and ferric radicals, or of the manganese radical in the manganous salts and in the manganates, are as different as those of separate elements. Indeed, such radicals would be regarded as distinct elements, were it not for the single circumstance that they can be so readily transmuted, and it is by no means impossible that hereafter the distinction between the different radicals of the same element may be found to be as fundamental as that between the so-called elements themselves, and any one who studies the different relations of the elements in their various degrees of quantivalance, will be strongly impressed with this idea.

* It is frequently asked what advantage has the new philosophy of chemistry over the old, to compensate for the greater difficulties it presents to the learner. Those who ask this question, evidently believe that the philosophy of chemistry is an arbitrary system, and regard that system which is the easiest—in the school boy sense—as the best; but unless the most eminent chemists of the world have been following, during the last ten years, a mere phantom, it is evident that it is not less absurd to teach a system of chemistry which ignores the law of Avogadro and the doctrine of atomicities, than it would be to teach a system of astronomy, which should ignore the law of gravitation.

ON SOME IMPROVEMENTS IN THE REFLECTING TELESCOPE.

By J. A. Hill.

Read before the American Association for the Advancement of Science, at Indianapolis, August, 1871.

It may not be amiss briefly to refer to a few points in the past history of reflecting telescopes, for the purpose of showing the gradual process of development which they have undergone, and the many obstacles which have presented themselves from time to time, in the efforts to increase the power and utility of such instruments; and also to show more clearly the relationship sustained by the plan which we now propose to the various others which have preceded it.

From the time that James Gregory and Sir Isaac Newton proposed the arrangements of mirrors and lenses, which have since borne their names, up to the present time, the success has indeed been most gratifying; as witness the marked improvements which have taken place under the direction of Short, Mudge, Edwards, Herschel, Rosse and others; the one or the other of these forms, or their various modifications, taking precedence in popular favor accordingly as they were adopted and improved from time to time by the ingenious men just mentioned.

But to the elder Herschel we are indebted for the production of the first telescope, which, passing all previous limits, were made of seven, ten, twenty, and finally of forty feet focal length.

Yet this latter instrument was liable to two important objections, viz.: 1st. The large and very heavy tribe to contain speculum, eye-piece, &c., requiring a very complex and unwieldy structure to give the proper support and motions to the tube, and also to enable the observer to follow the eye-piece from point to point, this being placed at the upper end of the tube in this construction: and 2d. The want of reflective power in the speculum. With the kind of mould then in use it was not possible to successfully cast specula, of true speculum metal, of any considerable size; hence the metal used in this large reflector was inferior in quality, having less reflective power and more liable to tarnish than that employed in the smaller and more perfect instruments.

Here then we find the limit was reached at that time in size, or rather should we not say was exceeded, considering the inferior quality of this monster telescope.

Your minds will now at once revert to the subsequent labors of

that ingenious nobleman the Earl of Rosse, one of the main results of whose numerous experiments was the construction of a mould, by means of which he cast successfully, and with comparative ease, mirrors of three and even six feet in diameter. These mirrors were composed of copper and tin united in their atomic proportions, which yielded, when ground and polished, a reflective surface of the most brilliant and permanent character. With some experience in the use of this mould, and taking into consideration the principles upon which it acts, I have no doubt that specula can be produced of any required size, with more certainty and far less trouble than was experienced in casting comparatively small ones on the old plan.

But when he came to mount for use his six-foot speculum, with a focal length of fifty-six feet, the speculum and box, together with the accompanying tube, weighing about fifteen tons, Lord Rosse found himself compelled to limit the motions greatly, there being only 15° of azimuth motion,thus largely diminishing its utility in various ways.

Still, although so circumscribed in motion, a necessity yet existed for an immense amount of mechanical appliances, such as walls, counterpoises, arcs, chains and windlass, moveable galleries, &c., &c., to direct the tube and enable the observer to follow it, this telescope, like Herschels', being built on the "Lee Maireau" or "front view" form; requiring the observer to be suspended in the air at a height of nearly sixty feet when looking at the zenith.

The plan suggested in this paper is an attempt to obviate this only remaining difficulty so far as construction is concerned, and to enable us to build telescopes without such limits, and of any required size, and which can be used with more of ease and comfort, no matter how large, than any yet made, either reflectors or refractors.

To accomplish this I propose to use two mirrors, operating substantially as shown in fig. 1. A represents a mirror circular in form, and ground on one surface to such concavity as to give the required focal length. B represents another mirror, oval in shape, and with the reflecting surface plane. The lesser diameter of this mirror should be equal to that of the concave one, and the larger diameter should be to the smaller as 5 or 6 to 4.

In the centre of this plane mirror is an oval hole, O, of such size as to allow the passage of the cone of rays thrown from the concave surface, D; the image being formed behind this oval mirror at K, and the eye-piece being applied as in the Gregorian and Cassegrainian styles.

The concave mirror is placed in a vertical position, so that the axis of said mirror shall coincide with a line running horizontally north and south, as c c in the figure. Opposite to this, and a little nearer to it than its focal length, is placed the oval mirror, which has two motions, one parallel to or coinciding with an imaginary axis, H H, passing through its lesser diameter, and the other about a hollow axis, placed at right angles to the former axis, and whose motion is made around the line c c as a centre. In this hollow axis the eye-piece is placed.

Parallel rays from an object, F, falling on to the plane mirror, B, will be reflected on to the concave surface, D, and from thence through the hole O in the plane mirror, forming an image at K which, being magnified by the eye-piece at S, will be seen by the eye at E.

Now, by moving the plane mirror around the line H H, it will be readily seen that any object from the zenith, M, to the horizon, N, may be viewed, and by moving it around the line c c running north and south any object between the eastern and western horizon may be viewed; thus embracing one-half of the visible heavens. These two motions correspond to the altitude and azimuth motions of other instruments. It will be observed that the eye remains in one position, looking in one direction all the time, wherever the object may be situated within those limits.

Now, by reversing the mirrors and looking in the direction of the same line, but in an opposite direction, the other half of the heavens can be seen.

To convert this instrument into an equatorial we have only to incline the mirrors, preserving their relative position, so that the imaginary line joining their centres shall be parallel to the axis of the earth, then by moving the oval speculum about this line as a centre, any siderial object can be followed by the one motion.

Fig. 2 represents a small instrument mounted as an equatorial. G is the stand or pedestal made of any suitable material, upon the top of which is fastened the bed-plate, R R, at a suitable inclination, by the bolts b b. At each end of this is an upright, S S, into which the axes of the telescope are laid. A is a shorter box with concave reflector; T is one of two bars fastened on to oppposite sides of box A. Between these bars at the opposite ends is placed the plane mirror B. Back of this the two bars are united by a cross piece, into which the hollow axis with eye-piece is placed. The mirror is fastened at any inclination by the thumb-screw 1. This is easily reversed by lifting it out of

its bearings; and when not in use may be kept in a suitable box; the stand and bed plate being permanently fixed in their positions. Fig. 3 shows an instrument of a larger size. At either end of the telescope a small room or observatory, A A, is seen, through the walls of which the hollow axis with the eye-piece passes, the observer being on the inside of the room. By means of suitable mechanical contrivances the proper motions are communicated from the inside to the mirror, C, thus enabling the astronomer to remain seated in *one* position, looking in *one* direction, and *entirely protected* from *cold, fatigue, night air*, &c. A very simple contrivance applied under the arms, T, will serve to sustain the weight, and also to reverse the instrument when required. This *telescope* also offers *unusual facilities* for *studying, drawing, mapping* or *photographing* the heavenly bodies. Any object which will admit of it may easily be photographed by darkening the room and placing a plate of the right size to receive the image properly prepared on a moveable screen, the size of the image being regulated by the distance from the eye-piece. This arrangement would enable *many persons to contemplate some of the celestial bodies*, such as the *sun, moon, &c.*, at the *same time.*

To construct an instrument on this plan of, say, 12 or 15 feet diameter and 150 or 200 feet focal length, let the ground be first levelled, and then the towers built at a suitable distance apart. Between these a double railroad track should be laid, the tracks running parallel to each other from north to south, and uniting in one curve at either end. The mirrors would be mounted separately on solid structures moveable on wheels, and thus would be easily reversible.

Differing as this does from all other constructions of telescopes, it will readily appear that a *great focal length is not objectionable*, it being as *easy to handle a mirror of* 1000 *feet focal length as one of the same size of* 50 *feet focus.*

To convert such an instrument into an equatorial select a piece of ground sloping to the south, grade to the exact inclination to give parallelism of the axis of telescope with that of the earth, the towers being built as usual if desired, and the mirrors mounted, the instrument may be used as an equatorial. Fig. 4 is a rough sketch of such an arrangement.

If it is desired to command a view of the whole heavens without reversing the mirrors in the usual manner, I would suggest that both

Fig. 1.

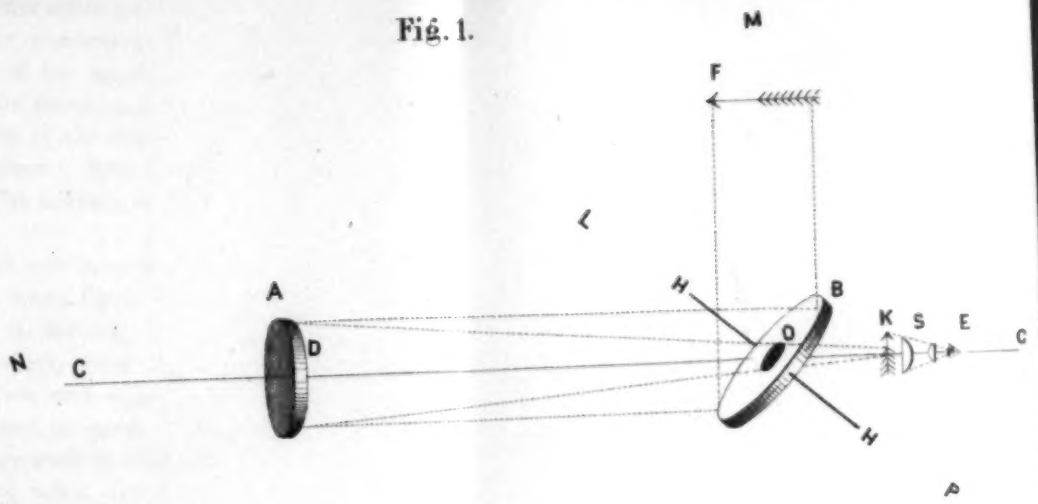
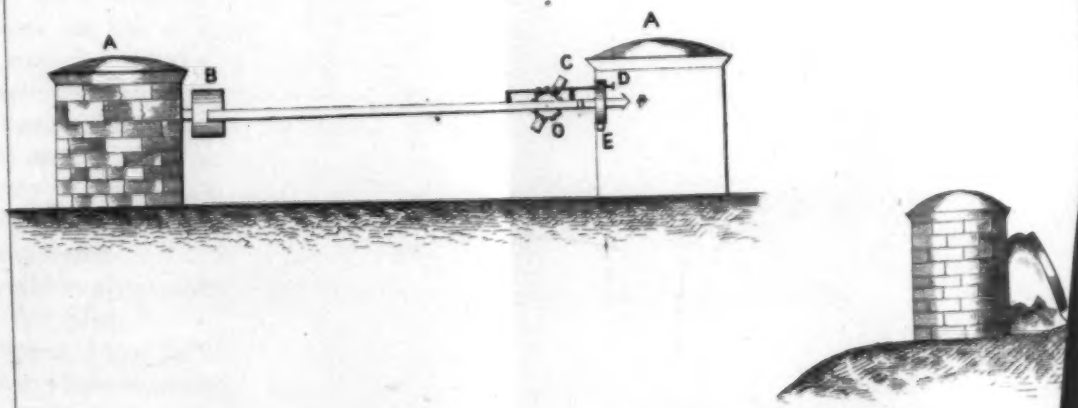


Fig. 3.



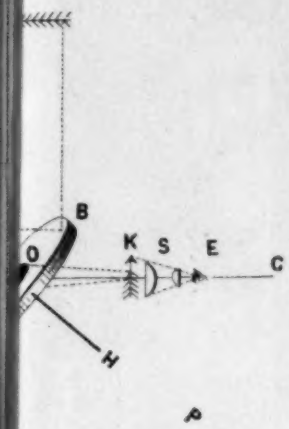


Fig.2.

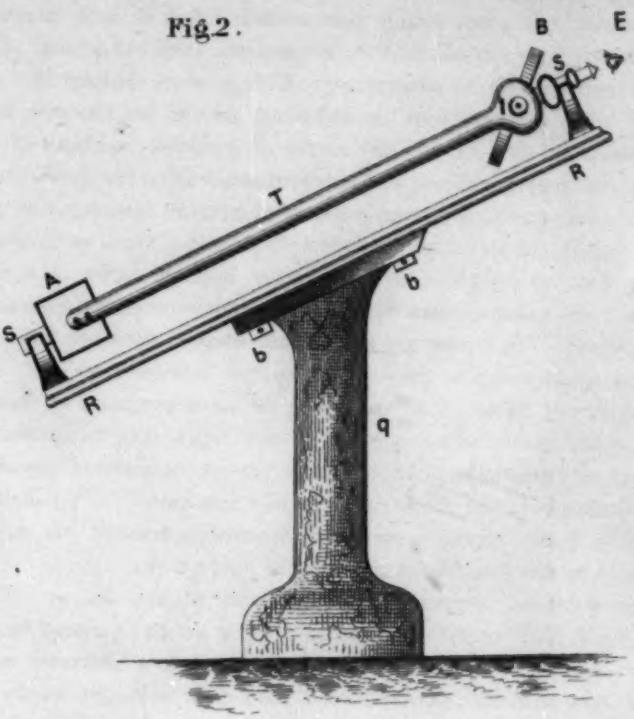
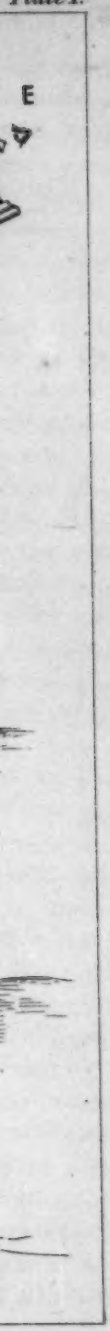


Fig.4.

Plate I.



sides of each mirror be used alternately, one side of each being made plane and the other concave.

Thus the concave side of the lower mirror being used with the plane side of the upper one, commands the southern heavens from the northern tower, and the plane side of the lower one used with the concave side of the upper, commands the northern heavens from the southern tower. Both mirrors in this case must be perforated in the centre. The mirrors, in this instance, may be solidly fixed in their positions.

As it has not been thought necessary to enter into deta , either as to the many forms this telescope may assume or to the great variety of mechanical devices for moving plane mirror or reversing the two mirrors, which would be adapted to those forms, a few words of comparison with other reflectors is all we shall add.

The tremor, so much complained of in some forms, having small specula supported on the ends of rods, or eye-pieces supported on the ends of long tubes, would be absent here, as the bearings are at each end, near the mirrors.

No tube is used for any size, but arms or bars connecting the specula may be used in the smaller sizes for convenience of handling, reversing, &c.

In illuminating power they are equal to all other telescopes having two mirrors, and inferior alone to the "front view" form, but superior to it in having no distortion of the image caused by inclining the mirror in that form, so as to throw the image to the side of the tube.

It is by far the simplest equatorial yet constructed, and the only one in which the line of sight, axis of instrument and axis of the earth all coincide. Clockwork may be added as in other equatorials, and a simple contrivance can be attached to the plane mirror, when the telescope is not in an equatorial position, which will give it a parallactic motion. This it is not necessary here to describe.

Simplicity of construction will enable these to be made much cheaper than others, especially if Faucault's plan of using glass mirrors be adopted.

One mould would answer for both mirrors, one side being convex and the other plane.

I am impressed that for any future enlargement of the boundaries of our observations we must look to the reflecting telescope, as it is impossible to construct refractors at all approaching the size which may be realized for mirrors.

The ratio of the illuminative power of a refractor and reflector of

equal aperture is usually considerod to be as 8 to 5. Still the Earl of Rosse succeeded in producing mirrors which were considered little, if any, inferior to an achromatic of equal aperture. The plane mirror might be made of blocks of speculum metal fastened on to a common basis and then ground and polished. Any slight deviation from a perfect figure would only cause a slight distortion, and not spherical aberration, as in the case of concave mirrors.

If telescopes, *far excelling in size and power* any yet made, shall be constructed, it is evident that the *enormous tubes*, with the *vast machinery to give the usual motions to those tubes must be dispensed with.* This arrangement of mirrors does that effectually, and it is doubted whether any other as simple can ever be devised, involving at the same time so many points of convenience and comfort in their use. The remaining difficulties of atmospheric inequalities, &c., are, of course, common to all instruments of any construction, and their discussion is not within the province of this paper.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 270.)

THE STEREOGRAPH.—DIFFERENCE BETWEEN THE TWO PICTURES, AND HOW TO DRAW THEM.

It was noticed in our last that variation of the optic angle, or binocular parallax, independently of all other conditions within its proper limits, produces the impression of increase or diminution of distance, and enables us to perceive relief when the objects themselves are looked at. Before considering the nature of the connection existing between this variation of the optic angle and our ideas of distance, and some other kindred questions which are matters of dispute, it will be best to consider the methods by which the effect of solidity, as perceived by the two eyes when the object itself is observed, may be reproduced by means of flat drawings of the object.

Our two eyes, in affording us indisputable evidence of the relief of objects, have two different views of those objects; the images delineated on the two retinæ are different. If the head were retained in one position, and a drawing made of an object as seen with one eye open, and then one as seen with the other eye open, the drawings would differ as truly as any drawings of an object made from different points of view. But since the eyes are only on an average about two and a half inches apart, the difference would perhaps in most

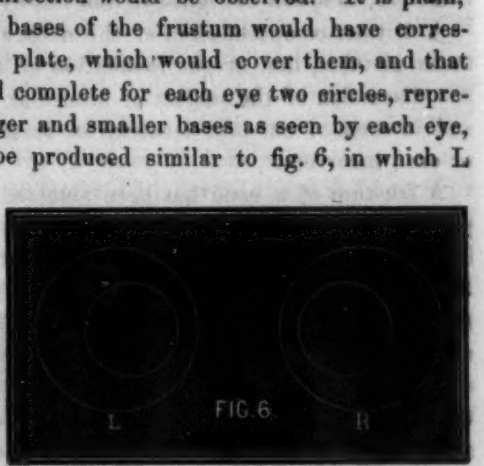
cases not be apparent, except upon close inspection. It is allowable, therefore, to speak of right-eye and left-eye pictures.

A distinct comprehension of the nature of the difference between these pictures, lies at the foundation of a correct understanding of any discussion of the subject of binocular vision and the stereoscope, and in some of our best treatises its statement is frequently obscure or even incorrect.

A frustum of a cone has been selected for the illustration of this point, because, whilst it affords one of the simplest cases of a solid, it has all the advantages of a diagram of simple points. In fig. 5, R represents the right eye, L the left eye, A B C D a frustum of a cone. It will be sufficient to consider the four points A, B, C, D, in the section of the frustum made by a horizontal plane, passing through the eyes, and the diameters of the bases. The dotted lines represent lines in vertical planes. The line *a b′* is the line of intersection of the horizontal and vertical planes. The lines from L and R to A, B, C, D, represent the optic axes, when these respective points of the frustum are distinctly seen, the eye, of course, being revolved with each change of point observed.

Suppose that a plate of glass be inserted vertically at *a b′*, it is evident, by inspection, that the four points A, B, C, D, as seen by the right eye, could be represented on the glass by points at *a′*, *c′*, *d′*, *b′*, or, in other words, that spots upon the glass at those points would completely hide the points A, B, C, D, and, as far as direction and distance are concerned, would produce the same impression on that eye. For the left eye *a b c d* would answer the same purpose. If both eyes were open, according to

previous statements, these dots would be located in their proper positions, distance as well as direction would be observed. It is plain, that all the points in the bases of the frustum would have corresponding points on the glass plate, which would cover them, and that these points together would complete for each eye two circles, representing respectively the larger and smaller bases as seen by each eye, or that a diagram would be produced similar to fig. 6, in which L would be the picture of the frustum as drawn by the left eye, R as drawn by the right eye.



A very perceptible difference is apparent here. It will be readily noticed that the small circle representing the nearer base is nearer the left edge of the larger circle, has its centre further to the left, in the picture, as seen by the right eye, and further to the right in that as seen by the left eye. The general rule may then be stated that, *in binocular pictures points nearer the observer—objects in the foreground—in the left-eye picture will appear further to the right than points more remote —objects in the background,—when compared with the same points, or objects, in the right-eye picture.*

Any stereograph, best not of a landscape, without marked foreground, because it lies in a great measure beyond the range of binocular effect, will verify this law. Objects in the foreground, in the left-eye picture, will be found to overlap, more to the right, objects in the background, than in the right-eye view. A tree, for example, some distance in front of a house, may appear entirely to the left of a window in the right-eye picture, whilst in the left-eye picture it may partially cover the window, or even appear on the right of it. A simple experiment may serve to render this clearer. Place an object —a lamp or, better, a rod—in a vertical position, on a table, several feet from the observer, so that it appears, viewed by both eyes, to be about in the direction of an object on the wall, the right-hand edge of a picture-frame, for example. Upon closing the right eye, the rod will appear projected upon the wall to the right of the picture-frame; upon closing the left eye, and retaining the head in its previous position, it will be found to cover a portion of the picture, or will appear

to the left of its previous position. If a second rod were placed between the first and the wall, a similar result would be noticed, except that its change of position would not be as great; it would not move as far to the right when seen by the left eye, nor as far to the left when seen by the right eye.

If drawings were to be made on the plane of the wall, or upon a pane of glass interposed between the eye and the first rod, by the right and left eyes alternately, it would be found that they would substantiate the rule laid down. The previous statements might have been made in reverse order—that is, that objects in the *background* appear further to the *left* in the left-eye view, and so forth, and after performance of the experiment given it would seem to be the more natural way of stating the fact, as, on alternately opening and closing each eye, the objects in the back-ground appear to march and countermarch past the rod in front. But, in making a practical application of the rule in assorting pairs of unmounted stereographs, it seemed most convenient, generally, to select an object in the foreground, and notice its projection upon some object in the background.

The experiment has been thus fully described because it has but recently been published, in a somewhat different form, in an article upon "The Stereograph," in one of our journals of high scientific character, but it is so stated that it is made to illustrate a directly opposite, and erroneous, result, and other statements are made, apt to mislead or confuse, in regar to the character of binocular pictures.

In some cases, and perhaps most frequently, the law of difference between the binocular pictures is differently stated. Inspection of figs. 5 and 6 will show that similar points of the circles representing the nearer base are nearer together than similar points of the circles representing the more remote base; or the rule may be stated that, in *the right and left-eye views of any object, when arranged with the right-eye picture on the right side, and the left-eye picture on the left side, the distance between similar points of objects in the foreground is less than the distance between similar objects in the background.* Any stereograph will afford a verification of this statement, if the distance between similar points in the foreground is compared with the distance between similar points in the background, by means of a pair of compasses. Or drawings may be made, which will exhibit relief, when united by means of the stereoscope, if this rule is adhered to. If, for example, two diagrams were desired, which, viewed by aid of the stereoscope, should produce the effect of a frus-

tum of a cone, with its smaller base more remote, all that would be necessary would be to make the distance between the similar points, or the centres of the interior smaller circles, fig. 6, greater than that between similar points of the larger circles, instead of smaller, as in the figure. Or, if a drawing of a geometrical solid is given, and a diagram desired which shall give, in connection with it, a view in relief, it is only necessary to pay attention to the above rule in order to execute it. Regarding the diagram, at will, either as a left or right-eye view, lay or draw it on a card; then, starting with the most remote point represented, lay off with compasses a point corresponding to it, about 2¾ inches to the right or left, and then points corresponding to nearer angles at a distance a little less, say ¹ of an inch, depending on the difference of distance from the observer to be represented; and, when points corresponding to all the angles have been laid off in this way, connect them by lines, and the stereograph will be complete. This method, theoretically, can be employed for all kinds of subjects, but practically its application is very limited. Thus, the delineation of the corresponding picture of a complicated view, as of a landscape, would not only be tedious, but impossible; much more so the delineation of a picture to supplement a drawing of a human countenance. But beautiful collections of crystal-models, optical diagrams, &c., can be produced in this way better than in any other. One point to be attended to is, that the difference of distance of points in the remote background should not exceed the difference of distance of objects in the extreme foreground by more than about two-tenths of an inch for the average interocular distance. The distribution of this difference of distance, between objects from background to foreground, depends, of course, upon their distances from the spectator, and is a subject of mathematical calculation; but, with a little practice, very good drawings of crystal-models can be made without mathematical distribution of this variation of distance. A very ingenious and practical method, and withal a comparatively rapid one, together with a simple instrument, was devised by Professor Rood for executing stereoscopic drawings by hand, and with it tables given for the distribution of the displacement from background to foreground. (Silliman's Journal, second series, Vol. xxxi, p. 71, 1861.)

If a picture of any object be taken photographically, by means of a camera, and the camera then be moved to the right or left about 2½ inches, and another picture taken, these two pictures would evidently

be right and left-eye pictures. In practice two lenses are usually attached to one camera, at about the interocular distance from each other, and the images formed by them fall upon the ends of the same glass plate, a partition in the camera preventing their overlapping on the central part of the plate. One advantage, in addition to others, in the use of two lenses, is that, since both pictures are taken at the same time, there will be no possibility of difference between the pictures owing to presence or absence of movable objects in one or the other, as might be the case when two exposures are necessary.

Since the images are formed by the lenses in an inverted position upon the plate, laterally as well as vertically, upon holding the plate in its proper position the right-eye picture will appear on the left side, and the left-eye picture on the right side. The same will be true of the paper prints taken from it, if it be used as a negative. In order, therefore, to view them in either case by means of the stereoscope, they must be cut apart and transposed.

Much has been written, and many rules have been given, in regard to the regulation of the distance between the lenses in photographing different objects, and different distances, in order to produce the best possible effect by the pictures in the stereoscope. It seems very evident that, in order to produce a natural effect such as is received by looking at an object with both eyes, the lenses, representing the eyes, in drawing the pictures, should be separated about as far as the eyes are. When this rule is observed, however, many views do not manifest that satisfactory, almost surprising relief, that was the charm of the stereoscopic combination of pictures upon the introduction of that instrument. In a landscape, for example, without very decided foreground, and that, perhaps by reason of this fact, reduced in extent in the picture, the prominent objects will lie beyond the range of binocular effect. Consequently an effort was made, and rules empirically established, to give to all subjects more or less decided effect in the binocular pictures. The lenses were separated several feet instead of inches, the binocular parallax increased, and pictures produced which would give an exaggerated, yet in some cases more interesting effect in the stereoscope. In views of this kind, and the writer has met with some Swiss views in the market, in which this artifice had been employed, and has taken them himself with a separation of eight feet for the lenses, the houses and other objects seem to stand out much more decidedly than would be natural, and seem more like toy affairs than realities, the view being, in fact, such as a

giant, with his eyes several feet apart, would get. Whilst it may be conceded, then, that some subjects may be improved by a wider separation of the lenses than three inches, as some landscapes, but more especially clouds, &c., it must be remembered that, in case of this further separation, objects in the foreground show a disposition to resist combination in the stereoscope, and if the separation of the lenses is very great, or the objects are in the immediate foreground, they cannot be made to combine. Whilst the safest distance for uniform practice is the natural one of about three inches, the thoughtful photographer pays great attention to the selection of a pleasing and decided foreground, which, since it falls within the range of binocular effect, will impart a pleasing character to the whole picture.

The apparently full discussion of this subject of the stereograph, incited in part by the article previously referred to, is more particularly due to the remembrance of the confusion occasioned by the manner in which it is discussed, and the carelessness in the arrangement of the figures, in perusiug for the first time Sir David Brewster's treatise on the stereoscope. (London, 1856.)

He gives a diagram, "fig. 19," of the character of fig. 5, in which, however, the plane of the smaller and nearer base is assumed as the plane of projection of the right and left-eye pictures, instead of a plane in front, as in fig. 5, and subsequently he gives a figure, "fig. 20," similar to fig. 6, except that the right and left-eye pictures are reversed; that is, the centres of the small circles are more distant than those of the larger ones. He then states: "If we now separate, as in fig. 20, the two projections shown together on fig. 19, we shall see that the two summits, C, D, *c*, *d*, of the frustum are farther from one another than the more distant bases, A, B, *a*, *b*, and it is true, generally, that *in the two pictures of any solid in relief, the similar parts that are near the observer are more distant in the two pictures than the remoter parts, when the plane of perspective is beyond the object.* In the binocular picture of the human face, the distance between the two noses is greater than the distance between the two right or left eyes, and the distance between the two right or left eyes greater than the distance between the two remoter ears." Now it seems clear that drawings upon the plane of the nearer base would not only be similar to, but occupy the same relative positions as, those made upon a plane somewhat nearer the observer, and these drawings would form a diagram similar to fig. 6, when "separated," as he suggests. The plane in front was selected, in fig. 5, simply to get

rid of the confusion occasioned by overlapping pictures on the plane of the nearer base.

But the rule laid down, in italics, by Sir David, although clearly independent of his diagrams, has so much of truth in it, that it is calculated to convey a false impression in regard to binocular views. It is true, fig. 5, that in a drawing on a plane beyond the frustum, the points 1 and 2, which represent the point A of the frustum in the right and left-eye pictures respectively, are nearer together than the points 3 and 4, which represent the nearer point C; but it will also appear at a glance that the picture, as seen by the right eye, preserves the character assigned to it according to the first statement of the rule. It is a drawing precisely similar to the drawing *a' b' c' d'*, made on the plane of projection in front. The small circle representing the nearer base is further to the left than the one that represents the more remote base. The left-eye view likewise preserves its character. In other words, if the left eye were closed, and a drawing of the frustum were made on a remote plane with the right eye, and the right eye then closed, and a drawing made with the left eye, these drawings would differ only in size from those made on the plane in front; and if the drawings were arranged with the right-eye picture before the right eye, and the left-eye picture before the left eye, the diagram would be similar to fig. 6, with the nearer points of the objects represented by nearer similar points. The rule for production of binocular views was first stated in that form because it embraced the essential conditions of difference in the right and left-eye pictures. The second statement of it depends upon the fact that the instruments usually employed in aiding the eyes in combining, so to speak, these dissimilar pictures, require the right-eye picture to be on the right side, the left-eye picture on the left side; but, had it been more convenient to construct and use an instrument,—and one could easily have been devised,—that would have required the right-eye view on the left side, and *vice versa*, in order to present to each eye its proper view, stereographs would have been generally so constructed, and the rule for their construction would have been that similar objects in the foreground should be farther apart than those of the background, and great trouble would have been spared in the preparation of photographic stereographs, because the similar pictures must be cut apart, or the negative must be cut previous to printing, in order to place them in the position now required. But, whatever arrangement the contrivance enabling us to unite them might demand, the picture for each

eye would retain its essential characteristics, as enunciated in the first general statement. It matters not in what way or by means of what instrument the right-eye picture is presented to the right eye,—thus producing the same retinal impression on that eye as the object itself, —and the left-eye picture to the left eye, or whether the optic axes have crossed each other in the production of the pictures on a remote plane, or have not so crossed, in their production upon the nearer and usual plane, the object will appear in relief in all cases in which the retinal impressions produced are such as the object itself produces. If, therefore, the pictures have been drawn on a remote plane, by crossing the directions of the optic axes, and their relative positions are preserved in the diagram, it will be necessary to cross the optic axes, or squint, in viewing them, so that each eye may see its own view; or the picture may be transposed and viewed without squinting, just as ordinary stereographs, produced on a plane in front, with the proper view before each eye, must be transposed, if viewed by crossing the optic axes in front, by squinting. It is because this last method of viewing stereographs seemed to present some advantages in the explanation of stereoscopic vision, that Sir David Brewster was led into the form of statement made, and the general confusion in discussion of this subject at the place mentioned, and subsequently in the eighth chapter of his book.

SPECTROSCOPIC NOTES.

By C. A. Young, Ph. D., Prof. of Natural Philosophy and Astronomy in Dartmouth College.

On the construction, arrangement and best proportions of the instrument with reference to its efficiency.

The spectroscope consists essentially of three parts—a prism or train of prisms to disperse the light, a collimator as it is called, whose office is to throw upon the prisms a beam of parallel rays coming from a narrow slit, and a telescope for viewing the spectrum formed by the prisms.

Supposing the slit to be illuminated by strictly homogeneous light, the rays proceeding from it are first rendered parallel by the object-glass of the collimator, are then deflected by the prisms and, finally, received upon the object-glass of the view-telescope, which, if the focal lengths of the collimator and telescope object-glasses are the same, forms at the focus a real image of the slit, its precise counter-

part in every respect except that it is somewhat weakened by loss of light and slightly curved.*

If the focal length of the view-telescope is greater or less than that of the collimator, the size of the image is proportionally increased or diminished.

This image is viewed and magnified by the eye piece of the telescope.

If now the light with which the slit is illuminated be composite, each kind of rays of different refrangibility will be differently reflected by the prisms, and form in the focus of the telescope its own image of the slit. The series of these images ranged side by side in the order of their color constitutes the spectrum, which can be perfectly pure only when the slit is infinitely narrow (so that the successive images may not overlap), and accurately in the focus of the object-glass of the collimator, which object-glass, as well as that of the telescope, must be without aberration either chromatic or spherical, and the prisms must be perfectly homogeneous and their surfaces truly plane.

Of course, none of the conditions can be strictly fulfilled. An infinitely narrow slit would give only an infinitely faint spectrum; and no prisms or object-glasses are absolutely free from faults. A reasonably close approximation to the necessary conditions can, however, be obtained by careful workmanship and adjustment, and it becomes an important subject of inquiry how to adapt the different parts of the instrument to each other so as to secure the best effect, and how to test separately their excellence, in order to trace and remedy as far as possible all faults of performance.

With reference to the battery of prisms, several questions at once suggest themselves relative to the best angle and material, the number to be used, the methods of testing their surfaces and homogeneity, and the most effective manner of arranging them.

Angle and material of the prisms.—As to the refracting angle the careful investigation of Professor Pickering, published in the American

* The curvature arises from the fact that the rays from the extremities of the slit, though nearly parallel to each other, make an appreciable angle with those which come from the centre. They therefore strike the surface of the prisms under different conditions from the central rays and are differently refracted, usually more. The higher the dispersive power of the instrument and the shorter the focal length of the collimator, the greater this distortion, which is also accompanied by a slight indistinctness at the edges of the spectrum.

Journal of Science and Art for May, 1868, puts it beyond question, that with the glass ordinarily employed an angle of about 60° is the best. For instruments of many prisms there is an advantage as regards the amount of light in making the angle such that the transmitted ray at each surface shall be *exactly* perpendicular to the reflected. For ordinary glass, the refracting angle determined by this condition somewhat exceeds 60°; for the so-called "extra-dense" flint it is a little less.

The high dispersive power of this "extra-dense" glass is certainly a great recommendation. But it is very yellow, powerfully absorbing the rays belonging to the upper portion of the spectrum, and is very seldom homogeneous. It is so soft also, and so liable to scratch and tarnish, that it can only be safely used by casing it with some harder and more permanent glass, as in the compound prisms of Mr. Grubb, and the direct vision prisms of many makers.

For many purposes these direct vision prisms are very convenient and useful, but they are hardly admissible in instruments of high dispersive power designed to secure accurate definition of the whole spectrum, the violet as well as the yellow.

Test for flatness of surface.—For testing the *flatness* of the prism surfaces, probably the best method is to focus a small telescope carefully upon some distant object (by preference the moon or some bright star), and then to scrutinize the image of the same object formed by reflection from the surface to be tested. Any general convexity or concavity will be indicated by a corresponding change of focus required in the telescope; any irregularity of form will produce indistinctness, and by using a card-board screen perforated with a small orifice of perhaps ¼ inch in diameter, the surface can be examined little by little, and the faulty spot precisely determined.

Test for homogeneity.—It is not quite so easy to test the homogeneity of the glass. Any strong veins may, of course, be seen by holding the prism in the light, and if the ends of the prism are polished, the test by polarized light will be found very effective in bringing out any irregularities of density and elasticity in the glass. A blackened plate of window glass serves as the polarizer; a Nicol's prism is held in one hand before the eye in such a position as to cut off the reflected ray, and with the other hand the glass to be tried is held between the Nicol and the polarizer. If perfectly good it pro-

duces no effect whatever; if not it will show more or less light, usually in streaks and patches.

On the whole, however, the method of testing which has been found most delicate and satisfactory is the following:

A Geissler tube containing rarefied hydrogen is set up vertically, and illuminated by a small induction coil.

A small and very perfect telescope of about six inches focus is directed upon it from a distance of seventy-five or one hundred feet, and carefully adjusted for distinct vision.

The prism to be tested is then placed in front of the object-glass of the telescope with its refracting edge vertical, adjusted approximately to the position of minimum deviation, and telescope and prism together then turned (by moving the table on which they stand), until the spectrum of the tube appears in the field of view. This spectrum consists mainly, as is well known, of three well-defined images of the tube, of which the *red* image, corresponding to the C line, is the brightest and best defined, and stands out upon a nearly black background.

Supposing then the *flatness* of the prism surfaces to have been previously tested and approved, the goodness of the glass may be judged of by the appearance and behavior of this red image, and by using a perforated screen in the manner before described, inequalities of optical density are easily detected and located. Irregularities, which would hardly be worth noticing in a telescope object-glass, where the total deviation produced by the refraction of the rays is so small, are fatal to definition in a spectroscope, especially one of many prisms, and it is very difficult to find glass which will bear the above-named test without flinching.

Of course it must be conducted at night, or in a darkened room.

Number and arrangement of prisms.—The number of prisms to be employed will depend upon circumstances. If the spectrum to be examined be faint, and either continuous or marked with dark lines, or by diffuse bands either bright or dark, we are limited to a train of few prisms.

The light of the sun is so brilliant that, in studying its spectrum, we may use as many as we please. The light is abundant after passing through 13, and I presume would still be so if the train were doubled.

Spectra of fine well defined *bright lines* also bear a surprising num-

ber of prisms. The loss of light arising from the transmission through many surfaces is nearly, if not quite, counterbalanced by the increased blackness of the background, and the greater width of slit which can be used.

As to the best arrangement for the prisms this also must be determined by circumstances.

Where exact measurements are aimed at, as, for instance, for the purpose of ascertaining the wave-length of lines, or the dispersion coefficient of a transparent medium, the prism or prisms ought to be firmly secured in a positive and determinable relation to the collimator. A train of many prisms can hardly be safely used in such work on account of the difficulty in obtaining this necessary fixity, and if high dispersion is indispensable, it can only be obtained by enlarging the apparatus.

But for most purposes it is better that the prisms, instead of being fixed, should be mounted upon some plan which will secure their automatic adjustment to the position of minimum deviation.

Having now thoroughly tried the plan which I proposed and published in this Journal last November, I am prepared to say that I cannot imagine anything more effective and convenient.

The arrangement of Mr. Browning and its extension by Mr. Proctor, are equally effective so far as the adjustment of the prisms is concerned, but are less compact and simple, and do not afford the same facility in changing the number of prisms in use.

In my instrument the light, after leaving the collimator, falls perpendicularly upon the face of a half-prism, passes through the train of prisms near their bases; at the end of the train is twice totally reflected by a rectangular prism attached to the last of the train (which is also a half prism), is thus transferred to the upper story of the train, so to speak, and returns to the view-telescope, which is firmly attached to the same mounting as the collimator and directly above it. Both are immovable, and the different portions of the spectrum are brought into view by means of the screw, which acts upon the last prism and through it upon the whole train. The adjustment for focus is by a milled head, which carries the object-glasses of both collimator and telescope in or out together. Since they have the same focal length, this secures the accurate parallelism of the rays as they traverse the prisms.

The annexed diagram, taken from the paper already alluded to*,

* After the appearance of the article referred to, I found that Mr. Lockyer

exhibits the plan of the arrangement and requires no explanation, unless to add that, to avoid complication in the figure, I have represented only two of the radial forks which maintain the prisms in adjustment; also, that the prisms are connected to each other at top and bottom not by hinges, but by flat springs, preventing all shake.

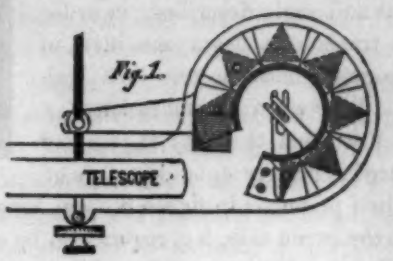
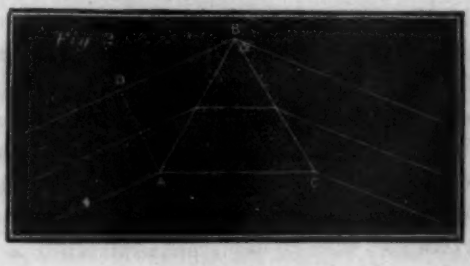


Fig. 1.

By adding another tier of prisms and sending the light back and forth through a third and fourth story, the dispersion can be easily doubled with very small additional expense, except for the prisms themselves; the mechanical arrangements remaining precisely the same.

I desire, in this connection, to call attention to the great advantages gained by the use of the half prism at the commencement of the train, a point which hitherto seems to have escaped notice.

With a prism of 60°, having a mean refractive index, μ, 1·6, and placed in its best position, the course of the rays is as shown in figure 2. The side, $a\,b$, is just $1\frac{3}{8}$ times the cross section, $a\,d$, of the transmitted beam. In



had anticipated me by some months, not only in respect to the method of making the rays traverse the prism train twice, but also in the use of a half prism at the beginning of the train, and the employment of an elastic spring in the adjustment for minimum deviation. In all essential particulars his instrument is the same as mine, though in some matters of detail there are differences which have proved to be of practical importance in favor of my own.

Mr Lockyer has, however, never printed an account of his instrument, and at the time of my publication I knew only the fact (which I then mentioned), that he intended to send the light twice through the prism train by a total reflection.

The beautiful instrument recently constructed for Dr. Huggins by Mr. Grubb, differs mainly in using compound prisms, and in producing the adjustment for minimum deviation by an arrangement of link work, which, though not theoretically exact, is practically accurate.

other words a prism of the material and angle described, in order to transmit a beam one inch in diameter, must be one inch high and have sides $1\frac{3}{4}$ inches long.

But when the light is received perpendicularly upon the face of a half prism, as in figure 3, then, since $b\ c = b\ e \div \cos 30°$, the length of the prism side, $b\ c$, requires to be only 1·155 times as great as the diameter of the transmitted beam.

Thus a train of prisms each 1 inch high, and having the sides of their triangular bases each 1·155 inches long, led by an initial half prism in the way indicated, would transmit a beam 1 inch in diameter, while without the initial half prism the sides would have to be 1·667 long, the surface to be worked and polished would be 1·44 (*i. e.* 1·667 ÷1·155) times as great, and the quantity of glass required 2·08 (*i. e.* $1{\cdot}44^2$) times as great. With a higher index of refraction the gain is still greater.

This advantage of course is not obtained without losing the dispersive power of one half prism. But where the train is extensive this loss is comparatively insignificant, and may be made up by a slight increase of the refracting angles. Indeed, in an instrument of the form above described, it is necessary, if the train is led by a *whole* prism, to reduce the refracting angle from 60° to about 55°, in order that the reflecting prism at the end of the train may not interfere with the collimator, while with the initial half prism, the full angle of 60° can be used, so that in this case there is practically no loss whatever.

It would seem to deserve consideration, whether in the construction of spectroscopes to be used with some of the huge telescopes now building, it may not be advisable to carry the principle still farther, by employing *two* or more half prisms at the beginning of the train in order to economize material and weight.

Dispersive efficiency.—The dispersive efficiency of a spectroscope is its ability to separate and distinguish spectral lines whose indices of refraction differ but slightly; it is closely analogous to the *dividing-power* of a telescope in dealing with double stars. It depends* not

* It is very common to describe the dispersive power of a spectroscope as being equivalent to a certain number of prisms, or a certain number of degrees from A to H. But either method fails entirely to convey an idea of the ap-

only upon the train of prisms, but also upon the focal lengths of the telescope and collimator, the width of the slit and the magnifying power of the eye-piece.

As has been said before, each bright line is an image of the slit whose *magnitude*, referred to the limit of distinct vision, depends upon the telescope and collimator, but is independent of the prism train. The *distance* between the centres of two neighboring lines, on the other hand, depends upon the number and character of the prisms, the focal length of the telescope and the magnifying power of its eye-piece, but is totally independent of the collimator.

In order that two lines may be divided, it is necessary that the *edges* of their spectral images should be separated by a certain small distance—a *minimum visible*, whose precise value is of no particular importance to our present purpose, but which I suppose to be about $\frac{1}{500}$ of an inch.

From these principles it is easy to deduce a formula which will express the dispersive efficiency of a given instrument, and enable us to judge of the effect of variations in the proportion and arrangement of the parts.

Let f be the focal length of the collimator.

f' " " " telescope.

m the magnifying power of the eye piece, (which is found by dividing the limit of distinct vision by the equivalent focal length of the eye-piece and adding unity to the quotient.)

n the number of prisms in the train.

w the width of the slit.

k the *mimimum visibile* above alluded to.

d μ, the difference between the indices of refraction for two adjacent lines, and finally

δ, the co-efficient of dispersion for each prism, (which, r being the refracting angle of the prism, is given by the equation

$$\delta = \frac{\sin \frac{1}{2} r}{\sqrt{1-\mu^2 \sin^2 \frac{1}{2} r}}\Big)$$

If, now, we put D for the distance between the centres of the two lines, and b for their breadth, we shall have

pearance of the spectrum in the instrument, and it is much better to name the closest double line which it will divide, or else to give the distance between the two D lines, either linear, (referred of course to the limit of distinct vision), or angular. If we know, for example, that the D lines are separated 1°, or, what comes to the same thing, appear to be one-sixth of an inch apart, we have a definite idea of the power of the instrument.

$$D = m\,n\,s\,\delta f^1.\ \mathrm{d}\,\mu, \text{ and}$$
$$b = m\,w\,f^1 \div f.$$

But the distance between the edges of the lines equals $D - b$; and this, for two lines as close as the instrument will divide, must equal k.

Hence $k = m\,n\,\delta f^1.\ \mathrm{d}\,\mu - \frac{m\,w\,f^1}{f}$. Finding from this the value of $\mathrm{d}\,\mu$, taking its reciprocal as a measure of the dispersive efficiency of the instrument, and calling it E, we get

$$\mathrm{E} = m\,n\,\delta\ \frac{f f^1}{kf + mwf^1}. \quad (1)$$

This formula, in which m, n and δ appear as simple factors, of course supposes that the perfection of workmanship and intensity of the light are such that there is no limit to the magnifying power and number of prisms which may be employed.

My special object, however, in working it out has been to exhibit clearly what is evident from its last term, the dependence of the dispersive efficiency upon the focal lengths of collimator and telescope.

Differentiating equation (1) with respect to f and f^1 we obtain

$$\mathrm{d}\,\mathrm{E} = m.\ n.\ \delta\ \left\{ \frac{kf^2(\mathrm{d}f^1) + mwf^1(\mathrm{d}f)}{(kf + mwf^1)^2} \right\} \quad (2)$$

which shows that any increase in either f or f^1 adds to the dispersion. If f increases, both D and b increase in the same proportion, and so, of course, does the width of the interval between the adjacent lines; while every augmentation of f^1 decreases the width of the spectral images without in the least affecting the distance between their centres.

This principle seems to have been often overlooked, and collimators and telescopes of short focus employed when longer ones would have been far better.

In spectroscopes designed to be used for astronomical purposes at the principal focus of a telescope, there is, of course, no advantage in making the angle of aperture of the collimator much greater than that of the equatoral itself; accordingly a collimator of one inch aperture ought to have a focal length of 10 or 12 inches, or, if special reasons determine a focal length of only 6 inches, then it is needless to make the collimator and view telescope much over half an inch in diameter, and the prisms may be correspondingly small.

If, on the other hand, the focus of telescope or collimator is lengthened for the purpose of securing increased dispersion, object glasses

and prisms must also be correspondingly enlarged, in order to transmit the same amount of light.

It is, perhaps, worth noting that when f and f^1 are equal formula (1) becomes simply

$$E = \frac{m.\ n.\ \delta.\ f}{k + mw}. \quad (3)$$

Luminous Efficiency.—The extreme faintness of many spectra greatly embarasses their study, so that it becomes a matter of interest to examine how the different dimensions and proportions of a given instrument stand related to the brightness of the spectrum produced.

It appears to be necessary, for this purpose, to distinguish two classes of spectra, those composed of narrow and well defined *bright lines*, and those which are not, the light being spread out more or less evenly and continuously.

The brightness of a spectrum of the latter kind is evidently directly proportional to the amount of light admitted, diminished by its subsequent losses, and inversely to the area over which it is distributed; similar considerations apply in the first case, only as the lines are exceedingly narrow images of the slit, their brightness, being independent of their distance from each other, is inversely proportional to the length of the lines simply—*i. e.* to the *width* of the spectrum, having nothing to do with its *length*.

Using the same notation as before, merely adding

i = intensity of source of light.

l = length of the slit.

a = linear aperture of the collimator object glass; and supposing the prisms and view telescope of a size to take in the whole beam transmitted by the collimator, and that the angular magnitude of the luminous object, as seen from the slit, is sufficient to furnish a pencil large enough to fill the collimator object glass, we shall then have for the quantity of light transmitted to the prisms the expression

$$i\,l\,w\frac{a^2}{f^2}.$$

This is afterwards diminished in passing through the prism train and telescope.

To estimate the precise amount of this loss is very difficult, and the algebraic expression for it is of so complicated a character that it would be of little use to attempt to introduce it into our formula. Calling it S, however, (which of course is a function of the number and refracting angle of the prisms, as well as of the optical character of

the glass) we may write for the quantity of light effective in forming the spectrum.

$Q = i l w \frac{a^2}{f^2} - S$. And this expression applies to both kinds of spectra—bright line and continuous.

In the continuous spectrum this light is spread out over an area whose length is the angular dispersion of the train $*\triangle$, multiplied by the magnifying power of the eye-piece and by the focal length of the view telescope, and whose breadth is the width of the spectrum. Putting A for this area we have

$$A = \frac{l m^2 n . \triangle . f_1^2}{f}.$$

And for the intensity of light in the continuous spectrum, which equals $Q \div A$, we get finally

$$L = \frac{i l w a^2 - f^2 S}{l m^2 n \triangle f_1^2 f}. \quad (4)$$

If we neglect the loss of light in transmission and take $f = f^1$, the formula simplifies itself to

$$L^1 = \frac{i w a^2}{m^2 n \triangle f} 3. \quad (5)$$

Either of these formulæ shows how rapidly the light is cut down by any increase of the dispersive power, whether by adding to the prism train or by enlargement of the linear dimensions of the apparatus.

Our only resource in dealing with spectra of this kind, when the limit of visibility on account of faintness is nearly attained, seems to be either to increase i or a. If the luminous object be a point (like a star) we can do the former by concentrating its light on the slit with a lens; if it be diffuse, like the light of the sky, I know no means for producing the desired concentration, and we can only gain our end by increasing the angular aperture of the collimator.

For the discontinuous bright-line spectrum the case is quite different. Q, *i. e.*, the quantity of light which goes to form the spectrum, remains unchanged, but instead of A the whole area covered by the

$*\triangle = n\ (\mathrm{Sin}^{-1}\ (\mu_H \times \mathrm{Sin}\ \frac{1}{2}\ r) - \mathrm{Sin}^{-1}\ (\mu_A\ \mathrm{Sin}\ \frac{1}{2}\ r))$ where μ_A and μ_H are respectively the indices of refraction for the lines A and H; the prisms being supposed to be so mounted as to maintain the position of minimum deviation.

spectrum we have only to consider its width, *i. e.*, the *length of the lines.

We then have $A^1 = \frac{l\,m\,f^1}{f}$;

and for the brilliance of the bright line spectrum we get

$$A = \frac{Q}{A'} = \frac{i\,l\,w\,a^2 - f^2\,S}{l\,m\,f\,f^1}. \quad (6)$$

If we neglect S, the loss of light in transmission through the apparatus, and suppose $f = f^1$ this becomes

$$A' = \frac{i\,w\,a^2}{m\,f^2} \quad (7)$$

These formulæ show that with a spectrum of this kind we may, without diminishing the brightness of the lines, increase the dispersive power of our instrument to any extent by increasing its linear dimensions; if we increase the dispersive power by adding to the prism train the case is different, since S is a function of n, the number of prisms.

New form of Spectroscope.—I close the article with the suggestion of a new form for a chemical spectroscope, which seems to present some advantages in the saving of material and labor as well as of light.

The figure sufficiently illustrates it, except that it may be necessary to add that I have not represented any of the many possible convenient arrangements for reading off the positions of lines observed. The centre of motion for the telescope is at c, the collimator remaining fixed.

The half prisms of heavy flint glass are concave at the rear surface and directly cemented to the single crown glass lenses, which form the object glasses of telescope and collimator. There is thus a saving of two surfaces over the common form; and what is more important,

*So long as the opening of the slit is small enough to secure accurate definition of the lines it is not necessary to take into account either this or the magnifying power as diminishing the brightness of the lines by increasing their breadth, since irradiation alone gives them a sensible width sufficient to render the effect of other causes comparatively unimportant.